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1705

Leybourn's Dialling IMPROV'D;

John Young

Or, The Whole ART Perform'd,

I. *Geometrically:* By Scale and Compaſſes, by
projecting the *Sphere* upon the *Plain*, whereby the
Reaſons of the Operations are demonſtrated.
II. *Arithmetically:* By Sines and Tangents.

ALSO,

How to deſcribe all neceſſary Furniture for SUN-DIALS,
as the Sun's Place and Declination; with
the *Babyloniſh*, *Italick*, and *Jewiſh* Hours, and the
Point of the Compaſs the Sun is upon at any Time
of the Day; and to make Dials to give the Time
of the Day at any Place propoſed, in any Part of
the World.

WITH

Reflective Dialling: Shewing how to make a
Dial that ſhall give the true Hour of the Day,
where the Sun cannot ſhine.

To which is now added,

Inſtrumental Dialling: By the Lines of Hours,
and Inclination upon the *Scales*, and likewiſe *Mechanick*
Dialling, whereby any Perſon may, without
Mathematicks, make a Dial upon any *Plain*;
with the Manner of ordering *Oyl* and *Colours* for
Painting SUN-DIALS.

Concluding with Tables ready calculated for all Latitudes
and Declinations, for the more expeditious
Drawing the Hour-lines upon any *Plain*.

By HENRY WILSON.

The THIRD EDITION, corrected and improv'd
By CHARLES LEADBETTER.

LONDON: Printed by H. PARKER, for
A. BETTESWORTH, at the *Red-Lion* in
Pater-noſter-Row. M.DCC.XXVIII.

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TO THE READER.

MR. *Leybourn*'s *Dialling* being known ſo univerſally to be a uſeful practical Piece, we thought we could not better oblige the World with a Work of that Kind, than by reviſing and improving what was of principal Uſe in it, and rendring it uſeful to all Capacities and Abilities; in order to which,

I. I have corrected the Errors in the Plates, and what was chiefly uſeful in the Theory and Practice of *Dialling*, in all its Varieties, and upon all Plains.

II. We have added what was wanting to make it compleat; amongſt which Additions, are, 1. An expeditious Method to find the Sun's Azimuth: 2. *Inſtrumental Dialling*, as performed by the Lines of Hours, and Inclinations, *&c.* upon the common Scales. 3. *Mechanick Dialling*, ſhewing how to make a Dial upon any Plain, without Mathematical Inſtruments, Trigonometrical Tables, or any Knowledge in the *Mathematicks*. 4. The ordering of Oyl and Colours for Painting of Dials; together with ſeveral Varieties, as making a Dial to know the Hour of the Day at any Part of the World, *&c.* Theſe, with other diverting Improvements, are added in this, which were never in any Impreſſion of *Leybourn's Dialling* before.

III. We have contracted the whole by reducing the Cuts, and engraving them on *Copper-plates*, whereby the Book, (tho' containing all the above-mentioned Additions) will come cheaper than the former Impreſſion.

I know it is a common Objection, that let a Book be never ſo plain, it is impoſſible to learn any Science, (whether *Dialling*, or any other) ſo well by a Book as with a Maſter. I anſwer, that may in ſome Meaſure be owing to a Want of due Order and Application in reading the Book; as for Inſtance, Suppoſe having this Book, and no Inſtructor, and it was required to make a *Horizontal Dial* in *Lead*, *Braſs* or *Stone*, turn to Page 37, and there you have ſuch plain Inſtructions, as if follow'd, you cannot miſcarry in your deſired Succeſs. Likewiſe, if it be required to make a *South Dial*, or a *Declining*, or *Reclining*, or *Inclining Dial*, &c. Look in the Table following, it will direct you to the Page, Chapter, and Section, where you have full Directions.

AND becauſe this Book may probably come into the Hands of ſome *Maſons*, *Carpenters*, or the like, in the Country, that have not attained ſo much Mathematicks, as to qualify them for underſtanding theſe Directions, I have, for that Reaſon, inſerted *Mechanick Dialling*, (Chap. 11. Page 215.) whereby any Perſon that can but read and write, may (by the Directions there given) make any Plain Dial, and perform the whole as well as they that have attained a greater Perfection in the Mathematicks.

I do not know of any Difficulty the Learner can be under, except in this, that having deſcribed the Hour-lines, &c. upon his Dial, yet there is not a

Painter preſent that underſtands the laying on of Colours in Oyl, ſo as to endure the Weather, and conſequently be fit for painting of Dials.

To prevent, or rather anticipate this Objection alſo, I have given Directions for the ordering of Oyl and Colours for painting of Sun-dials, (Page 254.) ſo that this Piece of *Dialling*, with all the above-mentioned Improvements, and others therein contained, and not here mentioned, I think, may, without Preſumption, be recommended to the World, as the moſt perfect Compendium of *Dialling* now extant; and if it be ſaid that Mr. *Good's* *Dialling* hath acquired the Name of a uſeful Book, it is eaſily proved, that it is in Part only a Copy of this, as will appear, by comparing the two laſt Plates in *Good's* *Dialling*, with Plate 9 and 10 in this Impreſſion of *Leybourn's* *Dialling*; and if an imperfect Copy, or Abſtract, be of Uſe, I hope much more the Original, with thoſe uſeful Additions with which it is now improv'd, by

A true Lover of the Mathematicks,

CHARLES LEADBETTER.

THE

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Geometrical Problems.

PROBLEM I.

Upon a Right Line given to erect a Perpendicular

DEFINITION.

A Right Line is ſaid to be perpendicular to another Line, when it maketh the Angles on either Side of the erected Line equal, that is, ſo that the Line inclines not either to the Right or to the Left, but ſtandeth upright upon the Line upon which it is erected, as in *Plate* 1. *Fig.* 1. the right Line A B is ſaid to be perpendicular to the Line C D, upon which it is erected, becauſe the Angles on either Side thereof are equal; namely the Angle A B C on the one Side, is equal to the Angle A B D, on the other Side, and either of theſe Angles are called *Right Angles*, and the Line A B ſo erected, is called the *Perpendicular.*

PRACTICE.

Let C D be a right Line given, and let it be required to erect a *Perpendicular* thereupon, from the Point B: Open your Compaſſes to any convenient ſmall Diſtance, and ſetting one Foot in the Point B, with the other, make the other two Marks E and F, on either Side of the Point B. —— This done, open the Compaſſes to any other convenient Diſtance greater than the former, and ſetting one Foot in the Point E, with the other draw the obſcure Arch G G, as near as you may gueſs over the given Point B. Again, (the Compaſſes being ſtill opened to the ſame Diſtance) ſet one Foot in the Point F, and with the other Foot deſcribe another obſcure Arch H H, croſſing the former in the Point A, ſo is A the Point, through which if you draw a right Line from the given Point B, that right Line A B ſo drawn, ſhall be perpendicular to the given Line C D, and from the Point B, as was required.

Plate 1. *Fig.* 1.

* * *

PROB. II.

How upon (or near) the End of a given right Line, *to erect a* Perpendicular.

To effect this, there are ſeveral Ways, but I will inſtance only in two, which are familiar and eaſy.

The

The Firſt Way.

LET A B be a Line given, and from the Point A, which is towards the End thereof, let it be required to erect a Perpendicular A C. ——Firſt open your Compaſſes to any ſmall Diſtance, and ſetting one Foot in the given Point A, with the other deſcribe the Arch F E D; then ſet one Foot of the Compaſſes in D, (they being open'd to the ſame Diſtance) croſs the Arch in E, and ſetting one Foot in E, with the other deſcribe the Arch A F G croſſing the firſt Arch in F.—— Again, ſet one Foot in F, and with the other deſcribe the ſmall Arch H H, croſſing the former in the Point C: So the Line A C being drawn, it ſhall be perpendicular to the given Line A B, and from the Point A, as was required.

Plate 1. *Fig.* 2.

The Second Way.

LET B be the Point given, and from it let it be required to draw the Line B I, perpendicular to A B. —— Open the Compaſſes to any ſmall Diſtance, and ſetting one Foot in the given Point B, pitch down the other Foot at all Adventures, as at K, ſo the one Foot being in K, turn the other Foot about till it croſs the given Line A B in L, then through L and K draw the Line L K M, and ſet the ſame Diſtance K L, from K to M, ſo the Line B I drawn from B, through M, ſhall be perpendicular to A B, and from the given Point B, as was required.

PROB.

PROB. III.

How from a Point above to let fall a Perpendicular *to a* right Line *given.*

IN this there are two Caſes. Firſt, when the Point above is over (or near) the middle of the Line. And Secondly, when the Point above is near over the End of the Line.

The Firſt Way.

Let R O be a right Line given, and from the Point P, over it, let it be required to let fall the Perpendicular P Q —— Firſt, open your Compaſſes to any Diſtance greater than P Q, and ſetting one Foot in the given Point P, with the other deſcribe an Arch of a Circle, cutting the given Line R O, in the Points R S. Then, Secondly, divide the Space between R and S in two equal parts in Q, (by the fourth *Problem* following) ſo a Line drawn from the given Point P to Q, ſhall be perpendicular to the given Line R O.

Plate 1. *Fig.* 3.

The Second Caſe.

Let V be the point given, from whence to let fall a *Perpendicular* to the Line R O, —— *Firſt*, from any part of the given Line R O, as from T, draw a right Line to the given point V, which Line (by the next *Problem*) divide into two equal parts in the point X, with that Extent of the Compaſſes (one Foot being placed in X) with the other deſcribe the Arch or Semicircle V O T, cutting the given Line R O in O, a Line drawn from V to O ſhall be perpendicular to the given Line R O, and towards the End thereof, as was required.

* * *

PROB. IV.

How to divide a right Line *given into two equal parts.*

LET the Line A B be a Line given, to be divided into two equal parts at right Angles. Take in your Compaſſes the length of the Line A B, or (if that be too long) any other Diſtance above half the length thereof, and ſetting one Foot in the End A, with the other draw the Arch C D E, (then the Compaſſes unaltered) ſet one Foot in B, and with the other Foot croſs the former Arch (both above and below the Line) in the points F and G; then a Ruler laid from F to G ſhall cut the given Line in H, ſo ſhall A B be divided into two equal parts in the point H, which was required.

Plate 1. *Fig.* 4.

* * *

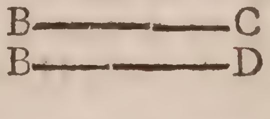
PROB. V.

A right Line *being given how to draw another* right Line, *which ſhall be parallel thereunto, at any Diſtance required, or through any Point aſſigned.*

DEFINITION.

OF *Parallel Lines* there are principally two kinds, *viz. Strait or Right Lined Parallels*, and *Circular Parallels.* All Circles that are deſcribed or drawn upon the ſame Center, whether they be greater or leſſer one than the other, are ſaid to be *Parallel* or *Concentrick Circles*, as *Plate* 1. *Fig.* 5. the Circle A B C D may be ſaid to be a *Concentrick Circle* with, or a *Parallel Circle* to E F G H, becauſe both of them are deſcribed or drawn upon the ſame Point or Center O; and of both theſe Circles, the right Line A C is the Diameter of the greater Circle, and E G of the leſſer, the point O is the Center of both, and all right Lines drawn from thence to the *Periphery*, *Circumference*, or *Limb* of either of the Circles, are equal, and are ſometimes called the Semidiameters, and ſometimes the *Radius* of the Circle, as the Lines O C or O B of the greater, and O H and O E of the leſſer; it containing 60 ſuch Degrees or Parts, of which the whole Circle contains 360.

But *Right Lined Parallels*, are ſuch right Lines, that being drawn upon the ſame Plain, and infinitely extended on either Side, would never concur or meet, but always in all parts retain an equal Diſtance, and ſuch are the right Lines B C, and B D, in the Margin.



In the deſcribing or drawing of *parallel Lines*, there may fall out two Caſes or Varieties: As,

1. It may be required to draw a *Right Line parallel* to another *Right Line*, at a Diſtance given.
2. It may be required to draw the *Parallel Line* through a Point aſſigned.

And of this kind there may be two Caſes; For,

1. The given Point may be over or under the given Line; Or,
2. It may be oblique to the given Line.

PRACTICE.

Of the Firſt Caſe.

Let E F be a right Line given, and let it be required to draw another right Line parallel thereunto, at the Diſtance of the Points G and H.

Take in your Compaſſes the given Diſtance G H, then ſetting one Foot of the Compaſſes in E, (or any other Point near the End of the given Line) deſcribe a ſmall obſcure Arch of a Circle, as I K: Then moving the Compaſſes to F, (towards the other End of the given Line,) deſcribe another obſcure Arch as L M; then lay a Ruler to the very Top of theſe two Arches, ſo that the Ruler do not croſs, but juſt touch either of them: Then by the ſide of the Ruler draw the Line N O, and it ſhall be parallel to the given Line E F, and at the Diſtance G H, which was required. *Plate* 1. *Fig.* 6.

The Second Caſe.

Let P Q be a right Line given, and let it be required to draw another right Line parallel thereunto, which ſhall paſs through the Point R.

First, ſet one Foot of your Compaſſes in the given point R, and with the other take the neareſt Diſtance to the given Line P Q, which is done by opening or ſhutting of the Compaſſes, till the moveable Point do only touch the given Line P Q, deſcribing the Arch s t. The Compaſſes ſtill reſting at this Diſtance, ſet one Foot in P, (or any other Points to the End of the given Line) and with the other Foot deſcribe the Arch u x. Laſt- *Plate* 1. *Fig.* 7.

ly, By the very Top of this Arch Y, draw the right Line Y R, and it ſhall be parallel to the given Line P Q, and ſhall paſs directly through the given point R, which was required.

The third Caſe.

LET A B be a right Line given, and let it be required to draw another right Line parallel thereunto, which ſhall paſs through the point C.

Plate 1. *Fig.* 8.

TAKE in your Compaſſes the Diſtance from the given point C, to the End of the given Line B, then ſet one Foot in A, the other End of the given Line, and with the other Foot deſcribe the Arch f g. Again, Take in your Compaſſes the length of the given Line A B, and ſetting one Foot in C, with the other deſcribe the Arch d e, croſſing the former Arch in the Point o, ſo the Line o C being drawn, ſhall be parallel to the Line A B, and ſhall paſs through the given Point C, as was required.

* * *

PROB. VI.

Any Three Points (which are not in a ſtraight Line) being given; how to find the Center *of a* Circle, *which ſhall paſs through thoſe three given Points.*

LET the three given Points be A B and C, through which it is required a Circle ſhould be deſcribed: Firſt, Set one Foot of the Compaſſes in one of the given Points as in A, and extend the other Foot to B, another of the Points, and draw the Arch of a Circle G E D. Secondly, The Compaſſes not altered, ſet one Foot in B, and with the other croſs the former Arch with two ſmall Arches, in the Points D and E, and draw the right Line D E. Thirdly, Set one Foot of the Compaſſes in the third Point C, (they ſtill keeping the ſame Diſtance) and with the other Foot croſs the firſt drawn Arch G E D, in the Points B and G, and draw the right Line E G, croſſing the former right Line D E, in the point O. So is O the Center ſought for; upon which, if you deſcribe a Circle at the Diſtance O A, it ſhall paſs through all the three given Points A B and C, as was required.

Plate 1. *Fig.* 9.

PROB. VII.

Two Points within a Circle being given, how to find the Center of a Circle, which being deſcribed, ſhall paſs through the two given Points; and ſhall alſo divide the Periphery or Circumference of the given Circle into two equal Parts.

THIS and the foregoing Propoſition, come in continual Uſe and Practice throughout this Work, and therefore ought more eſpecially to be minded.

Let the Circle given be A B C D, and the two Points within the ſame be E and F.

First, Through either of the given Points, (as E,) draw a right Line B E D, which muſt paſs through the Center of the given Circle at R.——

Secondly, draw the Line A C through the Center, and at right Angles to B E D. —— Thirdly, from the given Point E draw a right Line E A, and upon the End thereof A, (by the ſecond *Problem)* erect the Perpendicular A G, croſſing the Line B D, (it being extended) in the point G, ſo ſhall G be a third Point, and then having the three Points E F and G, (by the laſt *Problem)* you may find a Center, upon which a Circle being deſcribed, ſhall paſs, whoſe Center will be at H, without the given Circle, upon which point, if you deſcribe the Arch of a Circle at the Extent or Diſtance of H E, H F, or H G, it ſhall paſs through the two given *Points* E and F, and divide the given Circle into two equal parts in the points M and L, which was required. And that this Arch thus drawn doth divide the given Circle into two equal Parts, is evident; for a Line drawn from L to M will paſs directly through the Center of the given Circle, and ſhall therefore divide it into two equal parts.

Plate 1. *Fig.* 10.

* * *

PROB. VIII.

How to make a Line of Chords *Geometrically, to any aſſigned Length or Radius.*

FOASMUCH as through this whole Treatiſe, there is continual Mention and Uſe made of a *Line of Chords*, it will not be impertinent in this place to diſcover the making thereof, for the Convenience of ſuch, as at all Times, and in all Places, cannot have the Benefit of the *Mathematical Inſtru-*

Inſtrument Maker, to whom theſe Things are common.

DEFINITION.

A Line of Chords is no other than 90 Degrees of the Arch of any Circle, transferred from the Limb of a Circle to a ſtraight Line; now every Circle great or ſmall, is divided (or ſuppoſed to be ſo) into 360 equal parts, called *Degrees*, ſo the Semicircle contains 180, the Quadrant 90, and the Radius or Semidiameter (which is that Line upon which the Circle or Semicircle is deſcribed) noted in the following Figure with the Letters A B, is always equal to 60 Degrees of that Circle which it deſcribes, and therefore 60 Degrees of a *Line* of *Chords* is called the *Radius* thereof. Thus much for the Definition of a *Line* of *Chords*; now for

CONCLUSION.

FIRST, Draw a right Line of any length, as F B D, and near the Middle thereof, (by the firſt or fourth *Problem)* erect the Perpendicular A B.

Secondly, Open your Compaſſes to the Radius, or length that you would have your *Line* of *Chords* to be of, which ſuppoſe A B, and with that Diſtance upon B, as a Center, deſcribe the Quadrant R S A D.

Thirdly, Divide the Arch or Quadrant A R S D, into 90 equal parts or Degrees, which you may do in this Manner. (Take the Length of the Line A B, and ſet that Diſtance upon the Quadrant A D, from D to R, ſo is D R 60 deg. and A R 30 deg. Then take the Diſtance A R, and ſet it from D to S, ſo is the Quadrant divided into three equal parts, at the points S and R, each containing 30 deg. This done, divide the ſeveral Spaces between A R, R S, and S D, into three equal parts, each of which will be 10 deg. according as you ſee the Numbers ſet to them; theſe muſt be again divided into two equal parts, each part containing 5 deg. and every of thoſe into five ſmaller, as you ſee in the Figure, and ſo will the whole Quadrant be divided into 90.)

Fourthly, The Quadrant A R S D being thus divided into 90 parts or degrees, ſet one Foot of your Compaſſes in D, and open the other Foot to A, and deſcribe the Arch A E F, touching the Line F D in F, ſo is D F upon the right Line F D, the *Chord* of 90 deg.

Fifthly, Open the Compaſſes from D to 80 deg. and deſcribe the Arch 80 G H, ſo ſhall H be the *Chord* of 80 deg.

Plate 1. *Fig.* 11.

Sixthly, Open the Compaſſes from D to 70, and deſcribe the Arch 70 I K, ſo is D K the *Chord* of 70 deg.

Again, Open the Compaſſes from D to R, the Radius, or 60 deg. and deſcribe the Arch R L B, ſo is D B the *Chord* of 60 deg. equal to the Radius.

Do the like with 50, 40, 30, 20, and 10 deg. So ſhall you have the Line D F divided into 90 unequal parts called *Chords*.

In this Manner may you make a *Line* of *Chords* of any length, and ſet it upon a Ruler, and it is fit to perform all the Uſes in this Book; and it were convenient that upon one and the ſame Ruler, you had three, four, or five *Chords* of ſeveral Lengths or Radius's, or a Sector, which anſwers the ſame End, as in Practice you will find to be neceſſary and commodious.

Being thus provided of a Line of Chords, I will now ſhew you how to work two Concluſions Geometrically, which are of abſolute Uſe in Dialling, *the one is to find the Hour of the Day, and the other to find the Azimuth of the Sun at any Time, and in any Place. And with them I ſhall conclude theſe Geometrical and Aſtronomical Elements.*

ASTRONOMY.

FOR the better underſtanding of that which followeth, the Reader ought to be acquainted with the principal Circles of the Sphere; as alſo with ſuch other Lines and Points, as are deſcribed and noted upon the Material Sphere or Globe, in Imitation of thoſe which are imagined to be in the Heavens. And of ſo many of theſe as are neceſſary for this our preſent Purpoſe, I ſhall give you a brief Account.

DEFINITIONS.

A *Sphere* or *Globe* is a ſolid Body, containing only one Superficies, in whoſe Middle there is a Point, from whence all Right Lines drawn to this Superficies are equal.

THE principal Circles of which a Sphere or Globe is compoſed, are in Number ten; whereof ſix are great and four are ſmaller Circles.

A great Circle is that which divideth the Body of the Globe into two equal Parts or Hemiſpheres. A ſmall Circle is that which divideth the Globe into two unequal Parts.

The ſix great Circles are,

1. The *Horizon*,	4. The *Ecliptick*,
2. The *Meridian*,	5. } The two *Colures*.
3. The *Æquinoctial*,	6. }

The leſſer Circles are,

1. The *Tropick* of *Cancer.*	3. The *Artick* Circle.
2. The *Tropick* of *Capricorn.*	4. The *Antartick* Circle.

Of theſe in the Art of Dialling there are principally but five to be taken Notice of, *viz.* three great Circles, and two ſmaller Circles.

The great Circles are,

1. The *Horizon*,
2. The *Meridian*,
3. The *Æquinoctial.*

The leſſer Circles are,

1. The *Tropick* of *Cancer*,
2. The *Tropick* of *Capricorn.*

I. *Of the* HORIZON.

In the Figure, let the outermoſt Circle thereof, noted with the Letters HZON, repreſent a Sphere or Globe, then the Horizon is a Circle which divideth or ſeparateth the viſible Part of the Heavens which we ſee, from the invi-

Plate 1. *Fig.* 12.

ſible Part which we ſee not, and is repreſented in the following Figure by the Line (which repreſents a great Circle) H Q O, ſeparating the viſible Hemiſphere H Z O, which we ſee; from the inviſible Part thereof H N O, which we ſee not.

II. *Of the* MERIDIAN.

The Meridian is a great Circle of the Sphere which paſſeth by the Poles of the World, and through the Zenith and Nadir of the Place. To this Circle when the Sun cometh, he being above our Horizon, maketh Noon or Mid-day, and being in the ſame Circle, when it is under the Horizon, it is then Midnight.

Plate 1. *Fig*. 12.

The Zenith is that Point in the Heavens which is directly over your Head, in what Part of the World ſoever you be. And,

The *Nadir* is that Point in the Heavens which is under our Feet, directly oppoſite to the *Zenith.*

The *Meridian Circle* in this Figure is noted with the Letters H Z O N, the Point Z at the Top repreſenting the *Zenith*, and N the *Nadir* Points.

III. *Of the* ÆQUINOCTIAL.

The *Æquinoctial* is a great Circle of the Sphere, dividing it into the Northern and Southern Hemiſpheres, which take their Names from the two Poles, that being called the *Northern Hemiſphere*, in which the *North Pole* is ſeated, and that the *Southern*, in which the *South Pole* is ſeated.

ed. Unto this Circle, when the Sun in his annual Motion arriveth (which is but twice in the whole Year) the Days and Nights are of equal Length through the whole World.

THIS Circle cutteth the Axis of the World at Right Angles, and is ſeated in the Heavens 90 Deg. or a Quarter of a Circle, diſtant from either of the Poles.

IT is repreſented in this Figure by the Line or Circle Æ Q æ. The two Poles are noted with P and S; P being the *North* and S the *South Pole*; and ſo the Hemiſphere æ P Æ, is the *Northern*, and Æ S æ the *Southern Hemiſphere*. And the right Line P Q S is the *Axis of the World*, croſſing the *Æquinoctial* at Right Angles in Q, the Center, or middle Point of the *Sphere* or *Globe*.

IV. *Of the two* TROPICKS.

THE two *Tropicks* are ſmaller Circles of the Sphere, deſcribed parallel to the Æquinoctial Circle, and at 23 Deg. 29 Min. diſtant therefrom; that being the greateſt Declination that the Sun hath from the Æquinoctial towards either of the Poles. Of theſe Circles one is called the *Tropick* of *Cancer*, or Northern Tropick; the other the *Tropick* of *Capricorn*, or Southern Tropick, ſo denominated from the *Poles* which they reſpect or behold. As the Tropick of Cancer, marked with the Character of *Cancer*, ♋ ♋ at each End thereof beholdeth P, the *North Pole*, and the Tropick of Capricorn, noted with the Characters of *Capricorn*, ♑ ♑ at each End thereof, reſpecteth *S*, the *South Pole*.

THESE two Circles are the Bounds or Limits of the Sun's Courſe, for between them he always moveth, never going more Northward or Southward, (that is, declines not nearer to either of the *Poles)* than 23 Deg. 29 Min. Wherefore, when the Sun in his annual Courſe ſhall arrive to the Tropick of *Cancer*, which is about the 10th of *June*, he maketh the *Longeſt Days* to all that inhabit in the Northern Hemiſphere. And when he arriveth to the Tropick of *Capricorn*, which is about the 11th of *December*, he maketh the *Shorteſt Days* to thoſe that inhabit the Northern, and the *Longeſt* to thoſe of the Southern Hemiſphere.

Plate 1. *Fig*. 12.

Beſides theſe Circles here named, there are divers others deſcribed upon the Globe, two Sorts whereof are of great Uſe in Dialling.

Hour Circles, and *Azimuths.*

HOUR Circles are great Circles of the Sphere, which meet together in the *Poles* of the World, and croſs the Æquinoctial at Right Angles, of which the Meridian (or outward Circle in this Figure) is the Hour Circle of 12, the ſtreight Line P Q S, which repreſents the Axis of the World, is alſo the Hour Circle of Six, and all the reſt of the Hour Circles are drawn from *Pole* to *Pole* between them, as the Circle P A S, repreſents an Hour Circle, and ſo of all the reſt, which are 12 in Number, repreſenting the 24 Hours of the Day and Night being taken round the Globe or Sphere.

Azimuths are alſo great Circles of the Sphere, meeting together in the *Zenith* and *Nadir* Points, and fall upon, or interſect the Horizon at Right Angles; as the Hour Circles do the Æquinoctial. Of theſe Circles, the outermoſt Circle of this Figure repreſents the North and South Azimuth; and the Line Z Q N the Azimuth of Eaſt and Weſt, and is commonly called the *Prime Vertical Circle*. And all other Circles drawn through the *Zenith* and *Nadir* Points, and cutting the Horizon at Right Angles, are intermediate Azimuths between the Eaſt and Weſt, or the North and South Points. As in *Plate* 1. *Fig*. 12. the Circle Z B N is an intermediate Azimuth between the South and the Weſt.

EVERY Circle of the Sphere hath its proper *Poles*, which are always 90 Deg. diſtant from it in all Parts.

SO in the former Figure Z the *Zenith*, and N the *Nadir* Points, are the *Poles* of the Horizon, they being 90 Deg. diſtant from O the South Point, from Q the Weſt Point, and from H the North Point of the Horizon.

ALSO Q is the Pole of the Meridian Circle H Z O N, it being 90. Deg. diſtant therefrom in all Parts.

AGAIN, P and S, the North and South *Poles* of the World, are alſo the *Poles* of the Æquinoctial Circle, they being removed therefrom on either Side 90 Deg.

BUT the *Pole* of the Hour-circle P A S is at C, and the *Pole* of the Azimuth Circle Z B N is at D, and how to find theſe *Poles*, and alſo the *Poles* of any Oblique Circles, ſhall be diſcover'd in diverſe Places of the following Diſcourſe, where there is often Occaſion for the finding of them.

Note, *And whereas throughout this Book there is continual Mention made of Degrees and Minutes, know that a Degree is the 360th Part of any Circle, each of which Degrees is ſuppoſed to be divided into 60 Parts called Minutes, ſo that 45*

Min. is three Quarters of a Degree, 30 *Min. half a Degree, and* 15 *Min. one Quarter of a Degree,* &c.

THESE are ſuch *Aſtronomical Elements*, as I conceive, moſt neceſſary for the underſtanding that which follows;

IT reſteth now, that I ſhew how to perform two or three *Aſtronomical Concluſions* Geometrically, without which the Knowledge of making of a Dial will be of little Validity; for to what Purpoſe will a Dial ſerve without it be rightly placed? Or how can you make a Dial for any appointed Place, without you firſt know the Poſition or Situation thereof? And to theſe Purpoſes are the following Concluſions ſubſervient.

And becauſe it is requiſite to know at all Times of the Year, what Declination the Sun hath from the Æquinoctial either Northward or Southward, I have therefore at the End of this Introduction, inſerted two Tables, the one ſhewing the Sun's Declination every Day in the Year. And the other, a Table ſhewing the Latitudes of all the Principal Cities and Towns in England Scotland *and* Ireland.

PROB.

PROB. IX.

Having the Latitude of the Place, the Altitude of the Sun, and the Day of the Month given, to find the Hour of the Day, and Azimuth of the Sun.

LET the Place be *London*, whoſe Latitude is 51 deg. 32 min. North.— Let the Sun's Altitude be 45 Deg.—— And let the Day of the Month be the 11th of *May*, at which Time, by the following Table, the Sun's Declination is 20 Deg. 20 Min. North.

FIRST, Deſcribe the Circle H Z O N, repreſenting the Meridian of the Place; —— Croſs it at Right Angles with the two Diameters H Q O, for the Horizon, and Z Q N for the *Prime Vertical* Circle, or *Azimuth* of Eaſt and Weſt.

SECONDLY, Take 51 Deg. 32 Min. the Latitude of the Place, out of your Line of Chords, and ſet it from H to P in the North, and from O to S the South Pole; and draw the Line P Q S, for the Axis of the World. And becauſe the Æquinoctial Circle is in all Parts diſtant from the *Poles* of the World 90 Deg. take 90 Deg. of your Chord, and ſet them from P to Æ, and from *S* to æ, and draw the Line Æ Q æ for the Æquinoctial Circle.

THIRDLY, The Sun's Altitude given being 45 Deg. Take 45 Deg. from your Chord, and ſet them from H to A, and from O to T; and lay a Ruler either from H to T, or from G to A, and the Ruler will croſs the *Prime Vertical* Circle in L, through which Point the Circle of the Sun's Altitude muſt be drawn, and for the drawing of it you have three Points A L and T, wherefore by the 6th *Problem* beforegoing you may find its Centre, which will always be in the *Prime Vertical* Circle Z Q N extended.

FOURTHLY, The Sun's Declination for the Day propoſed, (*viz.* the 11th of *May*) being 20 Deg. 20 Min. Northward, therefore take 20 Deg. 20 Min. out of your Line of Chords, and ſet them from Æ to C, and from æ to D, towards P the North *Pole*, becauſe the Declination was North, otherwiſe it ſhould have been ſet towards *S* the South *Pole*. Then laying a Ruler either ftom Æ to D, or from æ to C, it will in both Caſes cut the Axis of the World in E, through which Point the Parallel of the Sun's Declination for that Day muſt be deſcribed, and for the drawing of it, you have three Points, D E, and C, whoſe Centre will always be in the Axis of the World S Q P, extended, and may be found by the former 6th *Problem*.

FIFTHLY, Obſerve in your Scheme, where the Parallel of Altitude A L T, and the Parallel of Declination D E C, do croſs each other, which will be at the Point ⊙, and that is the Place of the Sun at the Time of the Queſtion.

Plate 1.
Fig. 13.

SIXTHLY, By the fore-mentioned 6th *Problem*, draw an Hour-circle through the three Points P ⊙ and *S*, whoſe Centre will always be in the Æquinoctial Line extended, if Need be; alſo thro' the Points Z ⊙ and N, draw an Azimuth Circle, whoſe Centre will always be in the Horizon extended when Need requires.

THESE two Circles being thus drawn, your Scheme is prepared for the finding both of the Hour and Azimuth in this Manner.

I. *For*

I. *For the* HOUR.

LAY a Ruler to P, the *Pole* of the World, and G the Point where the Hour-circle croſſeth the Equinoctial, and the Ruler will cut the Circle in *a*. So the Diſtance from *a* to Æ being meaſured upon the Line of Chords, will be found to contain 41 deg. 48 min. which is the Hour of the Day, counted from Noon, which reduced into Time (by allowing 15 deg. to an Hour, and 1 deg. to 4 Minutes of Time) will be 2 Hours 47 Minutes, that is, either 47 Minutes afrer 2 in the Afternoon, or 13 Minutes after 9 in the Forenoon.

II. *For the* Azimuth.

LAY a Ruler to Z the Zenith, and to B the Point where the Azimuth Circle croſſeth the Horizon, and the Ruler will cut the Meridian Circle in the Point *b*, ſo the Diſtance *b* O being meaſured upon the Line of Chords, will be found to contain 62 deg. 8 min. And ſuch is the Sun's Azimuth from the South Part of the Meridian — Or the Diſtance N *b* being meaſured upon the Chords, will be found to contain 27 deg. 52 min. which is the Sun's Diſtance or Azimuth from either Eaſt or Weſt, according to the Time of the Day.

THUS by one and the ſame Projection of the Sphere, you have found both the Hour and the Azimuth, and many other Concluſions Aſtronomical might be wrought by this way of Projection, which I have more fully ſhewed in my *Geometrical Exerciſes*. But ſeeing that the *Azimuth* is of ſuch frequent uſe in Dialling, that nothing can be done to purpoſe without it, and that in this Way of Projection, ſometimes the Centres of the Circles will be very remote, I will here ſhew you another Geometrical Way, whereby you may find the *Azimuth* at any Time, and in any Place, by ſtraight Lines, which will be ſome Light and Eaſe to the Practitioner, that ſo he may compare one Way with the other in Caſe of any Doubt, which will be a good Confirmation of his Work.

Another Way to find the Azimuth.

LET the given Latitude be 51 deg. 32 min.

THE Declination North, 20 deg.

THE Sun's Altitude 40 deg.

AND let the Sun's Azimuth be required.

FIRST, Upon the Centre Q, deſcribe the Semicircle H Z O for half the Meridian, and upon Q, raiſe the Perpendicular Q Z.

Plate 1. *Fig.* 14.

SECONDLY, Set (by the Help of your Line of Chords) 51 deg. 32 min. the Latitude of the Place, from Z to Æ, and draw Æ Q for the Equinoctial.

THIRDLY, Set 20 deg. the Sun's Declination, from Æ towards Z, to the Point D, (being it is North) and draw the Line D T parallel to Æ Q, ſo is D B T the Parallel of the Sun's Declination.

FOURTHLY, Set 40 deg. the Sun's Altitude given, from O to L, and from H to M, and draw the Line M S L, for the Parallel of Altitude.

FIFTHLY, Take in your Compaſſes half the Length of the Parallel of Altitude S L, or S M, and with that Diſtance upon Q, deſcribe the innermoſt Semicircle.

SIXTHLY, Through the Point B, which is where the Parallel of Declination, and the Parallel of Altitude do interſect, erect the Perpendicular R C, till it touch the innermoſt Semicircle at C.

LASTLY, Lay a Ruler from Q to C, and it will cut the outermoſt Circle in E, ſo ſhall H E meaſured upon the Line of Chords, be 109 deg. 47 min. the Sun's Azimuth from the North Part of the Meridian.

E Z ſhall be 19 deg. 47 min. the Azimuth from Eaſt or Weſt. And,

E O ſhall be 70 deg. 13 min. the Azimuth from the South Part of the Meridian.

Having made this fair Preparative, I will here inſert the two fore-mentioned neceſſary Tables of the Sun's Declination, *and* Latitudes *of Places; and then proceed to the Art of* Dialling, *the Thing chiefly intended.*

A Table of the Sun's Declination.

Days	Januar.		Febru.		March		April		May		June	
	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.
1	21	44	13	46	3	24	8	36	18	5	23	12
2	21	33	13	26	3	0	8	58	18	20	23	16
3	21	23	13	5	2	37	9	20	18	35	23	19
4	21	13	12	45	2	13	9	42	18	50	23	22
5	21	2	12	25	1	49	10	3	19	4	23	24
6	20	50	12	4	1	25	10	24	19	18	23	26
7	20	38	11	43	1	1	10	45	19	31	23	28
8	20	26	11	21	0	38	11	0	19	44	23	29
9	20	13	11	0	0 South	14	11	27	19	57	23	30
10	20	0	10	38	0	10	11	47	20	10	23	30
11	19	46	10	16	0	33	12	7	20	22	23	30
12	19	32	9	54	0 North	57	12	28	20	34	23	30
13	19	18	9	32	1	21	12	48	20	45	23	29
14	19	3	9	10	1	44	13	7	20	56	23	28
15	19	48	8	48	2	8	13	27	21	7	23	27
16	18	33	8	25	2	31	13	46	21	17	23	25
17	18	17	8	3	2	54	14	5	21	27	23	23
18	18	2	7	40	3	18	14	24	21	37	23	20
19	17	45	7	17	3	41	14	42	21	46	23	17
20	17	28	6	54	4	5	15	1	21	55	23	14
21	17	11	6	31	4	28	15	19	22	4	23	10
22	16	54	6	8	4	51	15	37	22	12	23	6
23	16	36	5	45	5	14	15	54	22	20	23	1
24	16	18	5	21	5	37	16	12	22	27	22	55
25	16	0	4	58	6	0	16	29	22	34	22	50
26	15	42	4	34	6	22	16	46	22	41	22	44
27	15	23	4	11	6	45	17	2	22	47	22	37
28	15	4	3	47	7	7	17	18	22	53	22	31
29	14	45			7	30	17	34	22	58	22	23
30	14	26			7	52	17	50	23	3	22	16
31	14	6			8	14			23	8		

A

A Table of the Sun's Declination.

Days	July d.	July m.	Auguſt d.	Auguſt m.	Sept. d.	Sept. m.	Octob. d.	Octob. m.	Nove. d.	Nove. m.	Decem. d.	Decem. m.
1	22	8	15	12	4	24	7	15	17	40	23	9
2	22	0	14	54	4	2	7	38	17	56	23	13
3	21	51	14	36	3	38	8	0	18	12	23	17
4	21	42	14	17	3	15	8	22	18	28	23	20
5	21	32	13	58	2	52	1	45	18	43	23	23
6	21	22	13	39	2	29	9	7	18	58	23	25
7	21	12	13	20	2	5	9	29	19	13	23	27
8	21	2	13	1	1	42	9	51	19	27	23	29
9	20	51	12	41	1	19	10	13	19	41	22	29
10	20	40	12	21	0 North	55	10	35	19	55	23	30
11	20	28	12	1	0 South	32	10	56	20	8	23	30
12	20	16	11	41	0	8	11	18	20	21	23	29
13	20	4	11	21	0	16	11	39	20	34	23	28
14	19	51	11	0	0	39	12	0	20	46	23	27
15	19	38	10	39	1	3	12	21	20	58	23	25
16	19	25	10	18	1	26	12	41	21	9	23	22
17	19	12	9	57	1	50	13	2	21	20	23	19
18	18	58	9	36	2	13	13	22	21	31	23	16
19	18	43	9	15	2	37	13	42	21	41	23	12
20	18	29	8	53	3	0	14	2	21	50	23	7
21	18	14	8	31	3	25	14	21	22	0	23	2
22	17	59	8	9	3	47	14	41	22	9	22	57
23	17	44	7	47	4	10	15	0	22	17	22	51
24	17	28	7	25	4	33	15	19	22	25	22	44
25	17	12	7	3	4	57	15	37	22	33	22	37
26	16	56	6	41	5	20	16	1	22	40	22	30
27	16	39	6	18	5	43	16	19	22	46	22	22
28	16	22	5	56	6	6	16	37	22	52	22	14
29	16	6	5	33	6	29	17	54	22	58	22	5
30	15	48	5	10	6	52	17	11	23	4	21	56
31	15	30	4	47			17	28			21	52

A TABLE *of the* Names *and* Latitudes *of the* Cities, Towns, *and* Iſlands *in and about* Great Britain *and* Ireland.

England.	D.	M
Bedford	52	8
Berwick	55	50
Briſtol	51	27
Buckingham	52	0
Cambridge	52	12
Canterbury	51	17
Carliſle	55	0
Chicheſter	50	48
Cheſter	53	16
Colcheſter	51	58
Derby	52	58
Dorcheſter	50	4
Durham	54	50
Exceſter	50	43
Glouceſter	51	53
Guilford	51	12
Hertford	51	49
Hereford	52	7
Huntington	52	19
Ipſwich	52	8
Kendal	54	23
Lancaſter	54	10
Leiceſter	52	40
Lincoln	53	14

England.	D.	M.
London	51	32
Northampton	52	14
Norwich	52	41
Nottingham	53	0
Oxford	51	46
Reading	51	28
Salisbury	51	4
Shrewsbury	52	47
Stafford	52	52
Stamford	52	38
Truero	50	30
Warwick	52	20
Wincheſter	51	3
Worceſter	52	15
York	53	58

Wales.	D.	M.
Angleſey	53	28
Barmonth	52	50
Brecknock	52	1
Cardigan	52	12
Carmarthen	51	56
Carnarvan	53	16

Denpage 28.

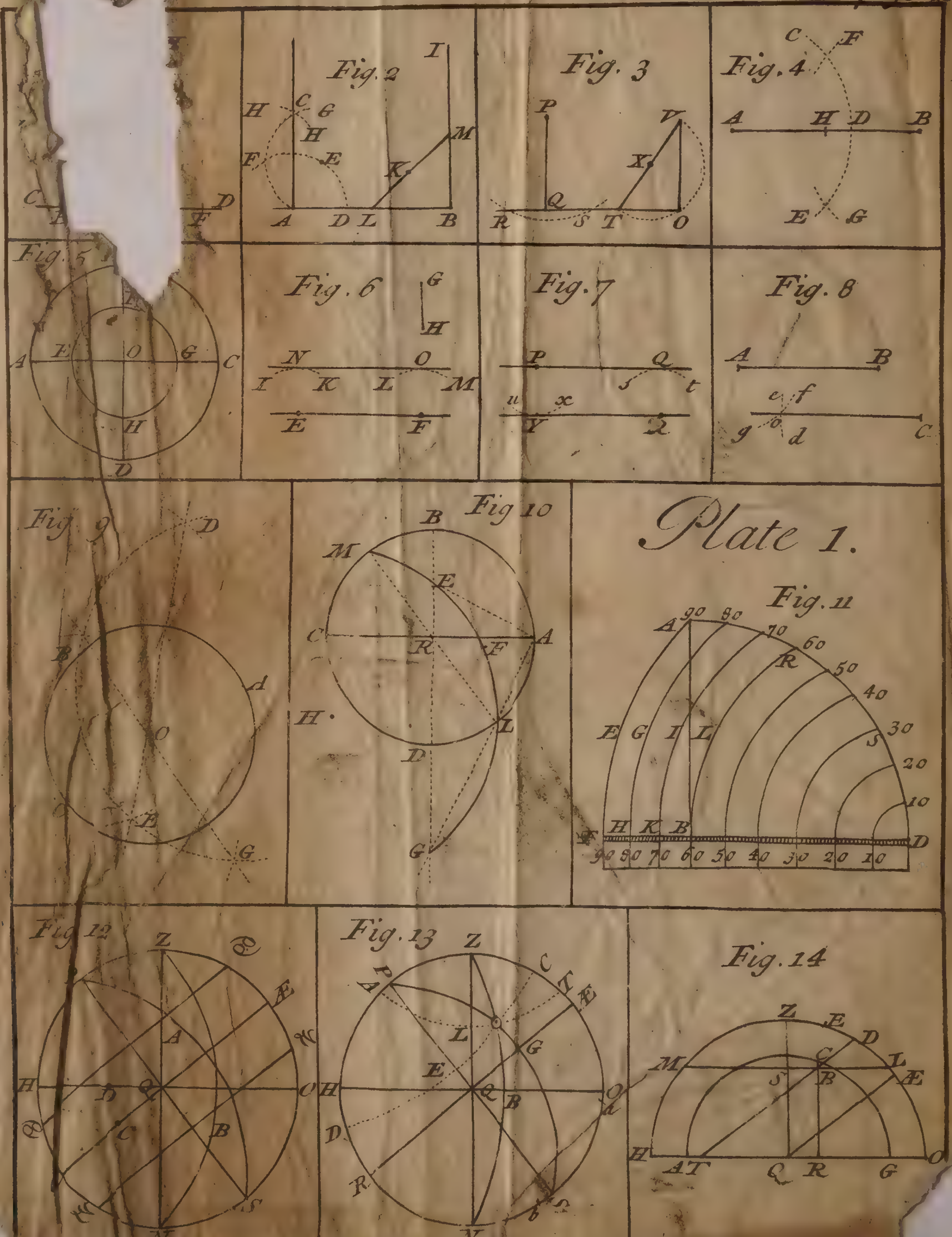


Plate 1.

Wales.	D.	M.
Denbigh	53	13
Flint	53	17
Landaff	51	35
Monmouth	51	51
Montgomery	51	56
Pembroke	51	46
Radnor	52	19
St. Davids.	52	0

Iſland.	D.	M.
GUernſey	49	30
Jerſey	49	12
Lundy	51	22
Man	54	24
Portland	50	30
Wight.	50	39

Scotland.	D.	M.
ABerdeen	57	32
Dunblain	56	21
Dunkel	56	48
Edinburgh	55	57
Glaſgow	55	53
Kinſale	57	44
Orkney	59	56
St. Andrews	56	39
Skyraffin	58	36
Stirling.	56	12

Ireland.	D.	M.
ANtrim	54	48
Arglas	54	10
Armagh	54	14
Caterlagh	52	41
Clare	52	34
Corke	51	50
Droghedagh	53	38
Dublin	53	20
Dundalke	53	52
Galloway	53	2
Kenny	52	27
Kildare	53	0
King's Town	53	8
Knockfergus	54	57
Kingſale	51	31
Lymerick	52	22
Queen's Town	52	52
Waterford	52	9
Wexford	52	13
Youghall	51	53

The

The ART of DIALLING

Geometrically perform'd,

By Projecting the *Circles* of the *Sphere* upon the *Plain* it ſelf.

The Firſt PART.

CHAP. I.

Of the ſeveral Sorts of Plains *upon which* DIALS *are uſually made.*

DIALS may be made upon any plain Superficies, and all plain Superficies are poſited in one or other of theſe three Poſitions, *viz.* either *Parallel*, *Perpendicular*, or *Oblique* to the Horizon of the Place wherein the Plain is ſeated, and all the Hour-lines drawn upon any Plain, are great Circles of the Sphere, which being projected upon a plain Superficies, become ſtraight Lines.

Now the Art of Dialling conſiſteth chiefly in the finding out of theſe Lines, and their true Diſtances each from the other, which do continually vary, according as the Plains upon which they are deſcribed or projected, are ſituated in reſpect of the Horizon of the Place.

Of theſe Plains there are but three Varieties. *viz.*

1. *Parallel* to the Horizon, as is the *Horizontal* (which I call *Vertical*) Plain only.
2. *Perpendicular* to the *Horizon*, and ſuch are all erect Plains. } which be either
   - Direct As
     - *North* & *South*
     - *Eaſt* and *Weſt*
   - Or *Declining*.
3. *Reclining* from the *Zenith*, or inclining to the *Horizon*. } and theſe are either
   - Direct
     - *North* } *Reclining*
     - *South* } *Inclining*
     - *Eaſt*
     - *Weſt*
   - Or Declining
     - *Reclining*
     - *Inclining*

Now in the making of particular Dials, which are in Number 25, I reduce them to 17, by ſupplying the *Inclining Plains* from their oppoſite *Recliners*, as being indeed the ſame.

And to avoid Miſtakes, which may poſſibly ariſe by comparing my Examples with other Authors, or others with mine: You are to take

Notice, that I denominate all my *Plains* from the Sight (or the Poſitions) of their *Axis* in the Heavens, and not from the Circles of the Sphere in which they lie: Therefore take Notice, That

Thoſe Plains which moſt
Writers call

	I call	Becauſe their Poles do lie in the
Horizontal	Vertical	Vertex or Zenith Point.
Vertical	North South } Direct	North South } Points of the Horizon.
Meridian	Eaſt Weſt } Direct	Eaſt Weſt } Points of the Horizon.
Equinoctial	Polar	Poles of the World.
Polar.	Equinoctial	Equinoctial Circle.

Again, all leaning Plains, whether Direct or Declining, whoſe upper Faces behold the *Zenith*, I call *Recliners*; and the nether, or under Faces of them, which reſpect, or look down to the *Nadir*, I call *Incliners*.

This Diſtinction being made, the Plains of all which Examples following, are thus denominated.

1. *Vertical* or *Horizontal*.
2. *South* and *North* Direct.
3. *Eaſt* and *Weſt* Direct.
4. *South* and *North*, declining *Eaſt* Or, *Weſt*.
5. *Eaſt* and *Weſt* Direct. *Reclining* Or, *Inclining*.
6. *Equinoctial*, Or, *South* Reclining or Inclining to the *Pole*.

7. 8. *South* Direct Reclining or Inclining leſs / more than the *Pole*.

9. *Polar*, Or *North* Reclining or Inclining to the *Equinoctial*.

10. 11. *North* Direct Reclining or Inclining leſs / more than the *Equinoctial*.

12. *Equinoctial*, Or *South* Declining *Eaſt* or *Weſt* Reclining to the *Pole*.

13. 14. *South* declining *Eaſt* or *Weſt* Reclining or Inclining. above / under the *Pole*.

15. *Polar* or *North* declining *Eaſt* or *Weſt*, Reclining or Inclining to the Equator.

16. 17. *North* declining *Eaſt* or *Weſt* Reclining or Inclining. above / under the Interſection of the Meridian & Equator.

Thus are the ſeveral Plains denominated, I ſhall now ſhew how the Situation of any Plain may be attained, either in reſpect of its Declination or Reclination.

CHAP. II.

How to find the Reclination *and* Declination *of any Plain.*

I. *For the* Reclination.

THE *Reclination* of a Plain, is the Arch of the Vertical Circle or Azimuth, which is perpendicular to the Reclining Plain, or that Azimuth, in which the *Pole* of the Reclining Plain lieth, comprehended between the Zenith of the Place, and the Reclining Plain.

Plate 2. *Fig.* 1. To find which, let A B C D be a *Reclining Plain*, draw firſt thereon by the Help of a Ruler and Quadrant, a Line G H parallel to the *Horizon* of the Place, which ſhall be the Horizontal Line of the Plain, and croſs at it right Angles with another right Line K S, for the Vertical Line of the Plain; to this Vertical Line K S, apply a ſtraight Ruler K I, and to that End of it which lieth clear of the Plain as I, apply a Quadrant as O L I; having a Thread or Plummet hanging from the Centre at I, then ſee what Number of Degrees of the Quadrant are contained between O and L, for ſo much doth the Plain recline from the *Zenith*.

II. *For the* Declination.

THE Declination of a *Plain*, is an Arch of the Horizon comprehended between the *Pole* of the *Plain*, and the *Meridian* of the *Place*. Or it is the Diſtance of the *Plain* itſelf, from the prime Vertical Circle, or Azimuth of *Eaſt* and *Weſt*.

To find out the Declination of any *Plain*, there are required two Obſervations to be made by the Sun at the ſame Inſtant of Time. The firſt of the Horizontal Diſtance of the Sun from the *Pole* of the *Plain*. And ſecondly, Of the Sun's Altitude.

1. To find the Sun's *Horizontal Diſtance* from the *Pole* of the *Plain*. Apply one Edge of a Quadrant to the Horizontal Line of your *Plain*. ſo that the other may be perpendicular to it, and the Limb of the Quadrant may be towards the Sun, and hold the whole Quadrant Horizontal (as near as you can conjecture.) Then holding up a Thread and Plummet at full Liberty, ſo that the Shadow of the Thread may paſs both through the Center and Limb of the Quadrant, obſerve then the Degrees cut by the Shadow of the Thread, and number them from that Side of the Quadrant that ſtandeth ſquare or perpendicular to the *Plain*: For thoſe Degrees are the Horizontal Diſtance required.

2. THIS Horizontal Diſtance and the Sun's Altitude being obſerved at the ſame Time, (as near as may be) will help you to the *Plain*'s Declination by the Rules following.

FIRST, By having the Altitude, you may find the Azimuth by the two laſt *Problems* of the Introduction, then by comparing the Azimuth and this Diſtance together, you may find the *Plain*'s Declination in this Manner.

WHEN you make your Obſervations of the Sun's *Horizontal Diſtance*, mark whether the Shadow of the Thread fall between the *South*, and that Side of the Quadrant which is perpendicular to the *Plain*.

1. IF the Shadow fall between them, the *Azimuth* and *Diſtance* added together, do make the *Declination* of the *Plain*, and in this Caſe the *Declination* is upon the ſame Coaſt whereon the Sun's *Azimuth* is.

2. IF the Shadow fall not between them, then the Difference between the Diſtance and *Azimuth* is the *Plain*'s Declination; and if the *Azimuth* be the greater of the two, then the *Plain* declines to the ſame Coaſt whereon the Sun is; but if the Diſtance be the greater, then the *Plain* declines to the contrary Coaſt.

AND here note, that the *Declination* thus found is always accounted from the *South*, and that all *Declinations* are counted from either *South* or *North*, towards either *Eaſt* or *Weſt*, and muſt never exceed 90 Degrees,

1. IF therefore the Degrees of *Declination* from the *South* do exceed 90, you muſt take the Reſidue of that Number to 180, and that ſhall be the *Plain*'s Declination from the *North*.

2. IF the Degrees of Declination exceed 180, then the Exceſs above 180 Degrees gives the *Plain*'s Declination from the North towards that Coaſt, which is contrary to the Coaſt whereon the Sun is.

I. Of *Vertical Dialling.*

CHAP. III.

How to draw the Hour-Lines upon a Vertical (commonly called Horizontal) *Plain.*

Example, Of a Vertical *or* Horizontal *Plain in the Latitude of* London, *which is* 51 *deg.* 32 *min.*

FIRST, Draw a Circle E S W N, which Circle let repreſent your Vertical Plain; croſs it in the Middle thereof at right Angles with the two Diameters, *viz.* S Q N, for the Meridian, and Hour-line of 12, and E Q W for the prime Vertical or Hour-line of 6.

SECONDLY, Becauſe the Latitude of the Place is 51 deg. 32 min. take 51 deg. 32 min. out of your Line of Chords, and ſet that Diſtance from S to *a*, and from W to *b*.

THIRDLY, Lay a Ruler from E to *a*, and it will cut the Meridian Line S N, in the Point P, which Point P is the *Pole* of the World: And a Ruler laid from E to *b*, will cut the Meridian in the Point Æ, ſo is Æ the Point where the Equinoctial croſſeth the Meridian; and thus have you three Points, viz. E, Æ, and W, through which you muſt draw the Equinoctial Circle E Æ W, whoſe Center will always be in the Meridian S N. So that you may eaſily find it, as hath been before taught, and in this Manner alſo. Draw the Line Æ W, which divide in two

A Vertical or Horizontal Dial for the Latitude of London, 51 deg. 32 min. *Plate* 2. *Fig.* 2.

two equal Parts in the Point A, upon which Point A, raiſe the Perpendicular A C, cutting the Meridian S N, in the Point C, which is the Center of the Equinoctial Circle E Æ W, upon which Point, and the Diſtance C Æ, you may deſcribe it.

Fourthly, Divide the Semicircle E N W, into 12 equal Parts at the Points ⊙ ⊙ ⊙, &c. beginning at the Point N, and ſetting 6 on either ſide thereof. The Semicircle may eaſily be divided into 12 Parts in this Manner; for 60 deg. of the Line of Chords will divide it into three equal Parts, and 30 deg. will divide each of them into two, that is, into 6 equal Parts, and 15 deg. is the half thereof, which is a twelfth Part of the Semicircle.

Fifthly, Lay a Ruler to Q, the Center of the Plain, and upon every of theſe Points ⊙ ⊙ ⊙, and the Ruler will cut the Equinoctial E Æ W, in the Points * * * &c. dividing that into 12 unequal Parts.

Sixthly, A Ruler laid to P, the *Pole* of the World, and the ſeveral Points * * *, &c. upon the Equinoctial, will cut the Circle repreſenting the *Plain* in the Points I I I, &c. dividing the Semicircle E N W, in 12 other unequal Parts.

Lastly, From the Point Q, and through the ſeveral Points I I I, &c. draw ſtraight Lines, as Q I 7, Q I 8, Q I 9, &c. they ſhall all be the true Hour-lines for ſuch a *Vertical* or *Horizontal Plain*. Namely, for twelve of them, that is, from 6 in the Morning till 6 at Night.

But for the Hours before and after 6, that is, for 4 and 5 in the Morning, and for 7 and 8 at Night, they are to be drawn by extending the Hour-line of 7 and 8 in the Morning through the Center Q, and drawing them on the other ſide of the *Plain*, ſo ſhall they be the Hours of 7 and 8 at Night: —— Alſo the Hour-lines of 4 and 5 in the Evening, being drawn through the Center Q, will become the Hour-lines of 4 and 5 in the Morning.

For the Stile of this *Dial*, take 51 deg. 32 min. the Latitude of your Place, out of your Line of Chords, and ſet them from N to *e*, upon the Circle of the *Plain*, ſo ſhall a Line drawn from Q through *e*, be the *Axis* or *Stile of the Dial*, which may be a thin Plate of Braſs, cut exactly to the Quantity of the Angle *e* Q N. 51 deg. 32 min. and ſet perpendicularly upon the Line of 12, or the Meridian S Q N, with the angular point at Q, and thus is your *Dial* finiſhed.

If into this, or any of the following *Dials* you have a Deſire to inſert the half Hours and Quarters, divide the Spaces between every one of the Points ⊙ ⊙ into two equal Parts for the Half, and into 4 equal Parts for the Quarters of Hours, and proceed with putting on of them in all Reſpects as you did with the whole Hours.

⁂

II. *Of Upright or Erect Plains.*

CHAP. IV.

THOSE *Plains* are ſaid to be *Erect* or *Upright*, which ſtand perpendicular to the *Horizon* of the *Place*, whoſe Vertex or upper Part tendeth to the *Zenith*, and their lower Part to the *Nadir*, and ſuch are the Walls of Steeples, Churches, Houſes, or the like, againſt which (for the moſt part) *Dials* are made.

Of theſe *Upright* or *Erect Plains* there are two Sorts, *viz. Direct* and *Declining*.

Those Erect or Upright *Plains* are ſaid to be direct, which do directly behold either the true Eaſt, Weſt, North or South Points of the *Horizon*, or whoſe *Poles* do lie direct in either of them, and theſe *Plains* are called *Erect Direct Plains*.

Those Erect or Upright *Plains* are ſaid to decline, which do not lie in, or directly behold any of theſe Points, but are ſituate under ſome other *Azimuth*, as *South-Eaſt*, *North-Weſt*, *North-Eaſt*, &c. and theſe *Plains* are called *Erect* or *Upright Declining Plains*. Of both which ſorts I ſhall give you Examples. And,

I. *Of Upright, or Erect Direct Plains.*

CHAP. V.

How to draw the Hour-lines upon a Direct South Plain.

Example, Of a Direct South Plain, *in the Latitude of* London, 51 deg. 32 min.

FIRST, Draw a Circle Z E W N, repreſenting an upright direct South Plain, croſs it at right Angles with the Diameter Z Q N for the Meridian, or Hour-line of 12, and W Q E for the prime *Vertical Circle*, or *Hour-line* of Six.

Secondly, Out of your Line of Chords take 38 deg. 28 min. (which is the Complement of the *Latitude* of the *Place*) and ſet that Diſtance upon the *Dial-plain* from Z to *a*, and from E to *b*, and from N to *e*.

THIRDLY, Lay a Ruler from W to *a*, it will cut the Meridian Z N, in the Point P, the *Pole* of the World; and a Ruler alſo laid from W to *b*, will cut the Meridian in Æ, ſo is Æ the Point through which the Equinoctial muſt paſs; and for the drawing of it you have three Points given, *viz.* E, Æ, and W, and the Center will always be in the Meridian Line Z N, (extended, if need be.) The Center you may find by the Geometrical Way taught at the Beginning of the Book. Or thus, draw the Line E Æ, and divide it into two equal Parts in A, upon A erect the *Perpendicular* A C, extending it, till that and the Meridian Line concur in G, ſo is G the Center of the *Equinoctial Circle* E Æ W.

An Erect Direct South Plain. Pl. 2. *Fig.* 3.

FOURTHLY, Divide the Semicircle E N W into 12 equal Parts, at the Points ⊙ ⊙ ⊙, *&c.*

FIFTHLY, Lay a Ruler to Q, and each of theſe Points ⊙ ⊙ ⊙, and the Ruler will croſs the *Equinoctial Circle* in the Points * * *, *&c.* dividing that into 12 unequal Parts.

SIXTHLY, Lay a Ruler to P, (the *Pole* of the World) and every of the Marks * * *, *&c.* and the Ruler will croſs the Circle of the *Plain* in the Points I I I, *&c.*

LASTLY, If through the Center Q, and the reſpective Points I I I, *&c.* you draw right Lines, they ſhall be the true Hour-lines of an *Erect Direct South Plain.*

FOR the Stile, take 38 deg. 28 min. the Complement of the Latitude of your Place, out of the Line of Chords, and ſet them from N to *e*, drawing the Line Q *e* for the Axis of the Stile, which muſt hang directly over the Meridian, or Hour-line of 12, and muſt point downwards towards the South *Pole*, becauſe the Plain beholds the South Part of the Meridian.

In making this Dial you have made two Dials, for the *Erect Direct North Dial* is but the back-ſide of the *South*, it lying in the ſame prime Vertical Circle, only as this beholdeth the South Part of the Meridian, and hath the South *Pole* elevated above it, the other beholdeth the North Part of the Meridian, and hath the North *Pole* elevated above it, and as the Meridian Line Z Q N in the South *Dial* repreſenteth the 12 a Clock Hour-line at Noon, the back-ſide thereof (namely the North-ſide) repreſenteth the Hour-line of 12 at Midnight, and therefore is not expreſſed, neither the Hour lines of 9, 10, 11 at Night, or of 1, 2, 3 in the Morning, the Sun to us never being above the Horizon at thoſe Hours: Wherefore the North Dial is only capable of receiving theſe Hours, namely, 4, 5, 6, 7 and 8 in the Morning, and of 4, 5, 6, 7 and 8 at Night, and (in this Latitude) not of all them neither; for it will never ſhine upon this Plain at 8 in the Morning, or at 4 in the Afternoon, but it is beſt to put them on (as in the Figure) that thereby you may know how much it is paſt 7 in the Morning, and how much it wants of 5 in the Afternoon.

An Erect Direct North Plain. Plate 2. *Fig.* 4.

CHAP.

p. 42.

Fig. 1

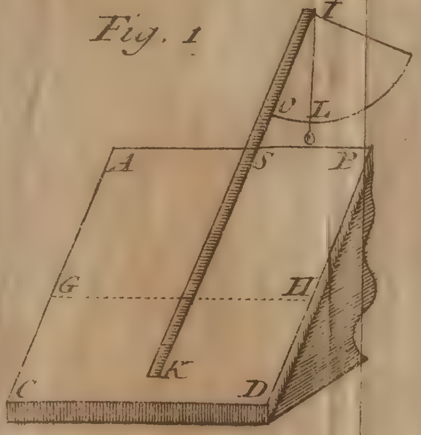


Fig. 2

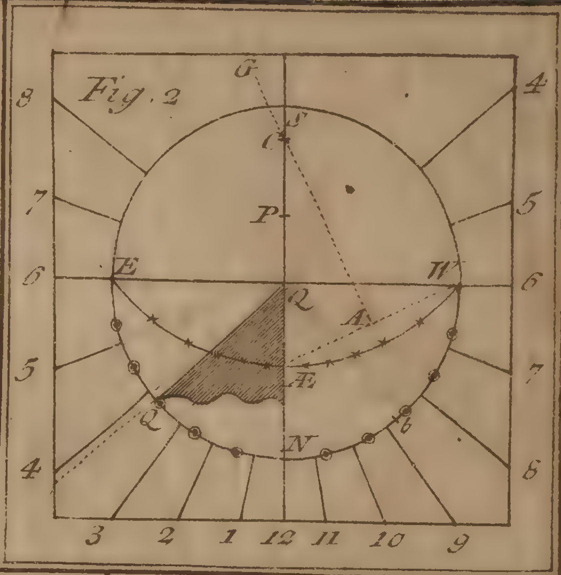


Plate 2

Fig. 3

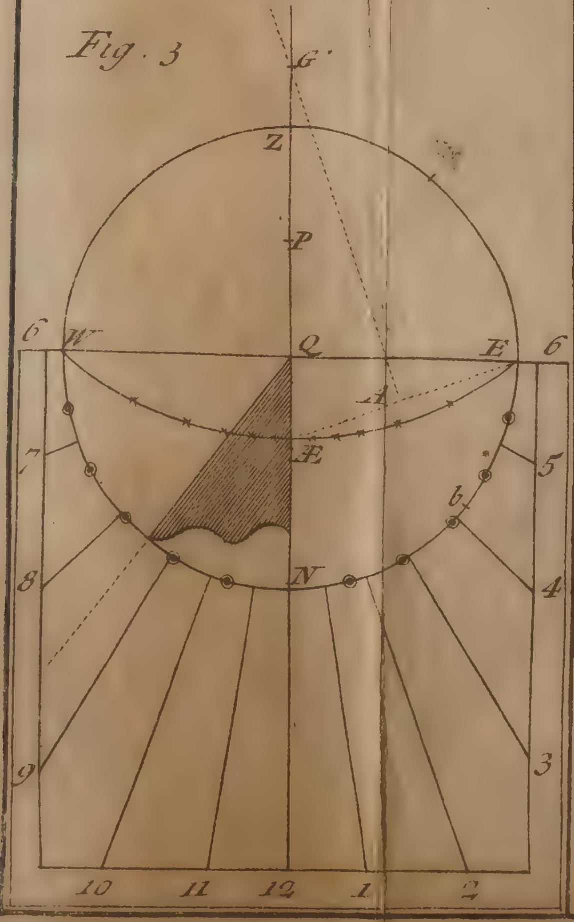


Fig. 4

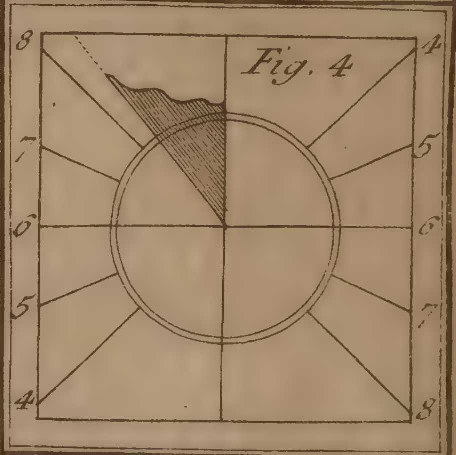
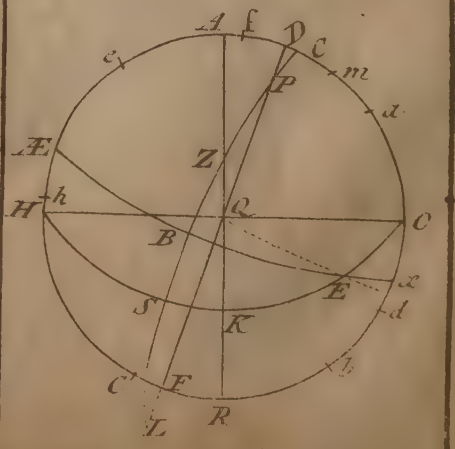


Fig. 5



CHAP. VI.

How to draw the Hour-lines upon an Erect, Direct, Eaſt, *or* Weſt Plain.

I Call that an *Eaſt* or *Weſt Plain*, which lies in the Meridian of the Place, and whoſe Poles lie in the Prime Vertical Circle, or *Azimuth* of Eaſt or Weſt.

Now for as much as the Plain lieth in the very Meridian Circle, in which alſo the two *Poles* of the World are ſeated, the Plain muſt neceſſarily paſs through both theſe Poles, and ſo neither of them can have any Elevation above it; wherefore the Hour-lines in theſe *Dials* muſt be parallel to one another, and conſequently parallel to the Axis of the World. And the Dial muſt have no Center: However the Dial may be drawn as followeth.

Example. Of an Eaſt Direct *Dial, in the Latitude of* London 51 *deg.* 32 *min.*

Let A B C D be a Dial-plain, upon which you would draw a direct *Eaſt Dial*, upon the Point D, if it be an Eaſt Dial; or upon the Point C, if it be a Weſt Dial; with the Radius (or 60 deg.) of your Line of Chords, deſcribe an obſcure Arch of a Circle E F, then from your Chord take 38 deg. 28 min. the Complement of the Latitude of the Place, (which is alſo the Height or Elevation of the Equinoctial) and ſet them from E to F, and draw the Line D F quite through the Plain. Then, that you may proportion your

An Erect Direct Eaſt Dial. Plate 3. *Fig.* 1.

Stile to your Plain, ſo that you may bring on all the Hours from Sun-riſing to 11 a Clock, aſſume two Points in the Line F D, one towards the End D (at the Point G) for the Hour-line of 11, and another at H, for the Hour-line of 6, and through the Points G and H, draw the Lines 11 G 11, and 6 H 6, perpendicular to the Equinoctial Line D F. This done, upon the Point G, with 60 deg. of the Line of Chords, deſcribe an obſcure Arch of a Circle I K, and ſet thereon 15 deg. of your Line of Chords from I to K, and draw the Line G K, to cut the Line 6 H 6 in the Point L, ſo ſhall L H be the Height of the perpendicular Stile proportioned to this Plain.

Now for the drawing of the Hour-lines, ſet one Foot of the Compaſſes, (opened to 60 deg. of the Chord) in L, and with the other deſcribe the Arch of a Circle M N, betwixt the Hour-line of 6, and the Line G L, which divide into 5 equal Parts in the Points ⊙ ⊙ ⊙ ⊙ ⊙, and a Ruler laid from the Point L to each of theſe Points, ⊙ ⊙ ⊙, &c. will cut the Equinoctial Line H D, in the Points * * * * *, through which Points draw Lines parallel to 6 H 6, as the Lines 7 * 7, 8 * 8, &c. and they ſhall be the true Hour-lines of an *Eaſt Plain*, from 6 in the Morning till 11 before Noon, but for the Hours of 4 and 5 in the Morning, you may put them on by ſetting the ſame Diſtances upon the Equinoctial Line before 6, as there is from 6 to 7 and 8, after 6; and through thoſe Points draw the Hour-line of 4 and 5, parallel to the Hour of 6, as you ſee done in the Figure.

Thus is your *Dial* finiſhed, and in the making of it you have made two *Dials*, namely, a *Weſt Dial* as well as an *Eaſt*, for it is the ſame in all Reſpects.

ſpects. Only whereas the Arch A F through which the Equinoctial paſſeth in the Eaſt *Dial*, was drawn on the Right-hand of the Plain, in the Weſt it muſt be drawn on the Left-hand, and the Hour-lines of 4, 5, 6, 7, 8, 9, 10, and 11, in the Forenoon on the Eaſt Dial, muſt be 8, 7, 6, 5, 4, 3, 2, and 1 in the Afternoon upon the Weſt Dial.

An Erect, *Direct Weſt Dial. Plate* 3. *Fig*. 2.

The Stile of the Eaſt or Weſt *Dials* may be either a ſtrait Pin of the juſt Length of the Line H O, which is equal to H L in the Eaſt Dial, fixed in the Point H, upon the Hour-line of 6, and exactly perpendicular to the Plain, ſhewing the Hours of the Shadow of the Apex, or very Top thereof.

Or, it may be a Plate of Braſs of the ſame Breadth with the Diſtance between the Hour-lines of 6 and 3, which Plate muſt be ſet perpendicular upon the Hour-line of 6, and ſo it will ſhew the Hour by the Shadow of the upper Edge thereof, as in this Weſt Dial.

These five Dials here deſcribed, *viz*. the *Vertical*, the *South*, *North*, *Eaſt*, and *Weſt* Erect, Direct, may be made upon a Stone cut ſquare in form of a *Die*, which Body is called a Cube.

* * *

II. *Of Upright Declining Plains.*

CHAP. VII.

How to draw the Hour-lines upon a South or North Erect Plain, Declining *either* Eaſt *or* Weſt.

THE upright or erect Plains, that we have hitherto treated of, are ſuch as did directly behold the four Cardinal or principal Points of the Horizon, namely, the *Eaſt*, *Weſt*, *North* and *South* Points. All other upright Plains are ſaid to decline, and their Declination is counted from the North or South, towards Eaſt or Weſt, and theſe Plains are called South or North Erect Plains declining Eaſt or Weſt.

BEFORE the Hour-lines can be drawn upon any of theſe Plains, two Things muſt be given, and three other Things muſt be found. ——

The Things given muſt be,

1. The Latitude of the Place.
2. The Declination of the Plain.

The Things required are,

1. The Height of the *Pole* (or *Stile*) above the Plain.
2. The Diſtance of the *Subſtile* from the Meridian, or 12 a Clock Hour-line.
3. The *Plain*'s Difference of Longitude.

FOR the finding of theſe, we muſt project upon the *Plain* ſuch Circles of the Sphere (in their true

Poſitions) as are requiſite for the finding of them, and thoſe Circles are, the *Horizon*, the *Meridian*, and the *Equinoctial:* Which I ſhall ſhew how to perform by giving an

Example of a South Erect Plain, *declining* Weſtward 24 *deg.* 20 *min. in the Latitude of* London 51 *deg.* 32 *min.*

		d.	*m.*
Given	Latitude of the Place	51	32
	Declination *South Weſt*	24	20

		d.	*m.*
Required	Diſtance of the Subſtile from the Meridian,	18	8
	Height of the Pole (or Stile) above the Plain,	34	33
	Plain's Difference of Longit.	30	00

To find which,

Firſt, Deſcribe the Circle Z H N O, repreſenting the declining Plain, croſs it at right Angles, with the two Diameters Z Q N, and H Q O, the Point Z repreſenting the Zenith, and N the Nadir, and the Line Z Q N, the vertical or perpendicular Line of the Plain (and the Hour-line of 12) and the Line H Q O is the Horizontal Line thereof.

Secondly, Becauſe the Plain declines 24 deg. 20 min. from the South Weſtward, ſet 24 deg. 20 min. from N to *a*, and from O to *c*. Then lay a Ruler from Z to *a*, and it will cut the Horizontal Line H Q O in S, ſo is S the South Point of the Horizon, through which the Meridian muſt be drawn, and for the drawing of it you have three Points, *viz.* Z S and N, and the Center

An Upright Plain Declining from the South Weſtward 24 *d.* 20 *m. Plate* 3. *Fig.* 3.

will always be in the Horizontal Line H Q O, extended if need be. Which Center may be found *Geometrically*, as is formerly taught. Then lay a Ruler from Z to *c*, and it will cut the Horizon in W, the Weſt Point thereof.

Thirdly, Having drawn the Meridian and the Horizon, take 51 deg. 32 min. out of your Line of Chords, and ſet them upon your Plain, from H to *b*, and from N to *d*.

Fourthly, Lay a Ruler upon W, the Weſt Point of the *Horizon*, (which is alſo the Pole of the Meridian) to *b*, and it will cut the Meridian in the Point P, ſo ſhall P be the Pole of the World, through which Point P, and Q (the Pole of the *Plain*) draw the ſtrait Line B P Q D, repreſenting the Axis of the World, and the Subſtilar Line of the Dial.

Fifthly, Lay a Ruler from W to *d*, and it will croſs the Meridian in the Point Æ, ſo is *Æ* one Point in the Meridian, through which the Equinoctial muſt paſs: And the Point W in the Horizon is another. So have you two Points within the Circle, by which to draw the Equinoctial, which you may do *Geometrically*, as is before taught. Or you may find it thus, the Center of the Equinoctial will always be in the Axis of the World, and therefore in the Line B P Q D. Now to find the Point, draw the Line Æ W, which divide into two equal Parts in the Point *n*, upon *n* erect a Perpendicular, till it cut the Axis of the World, extended in *m*. So is *m* the Center of the Equinoctial, upon which Point you may deſcribe it. And thus have you drawn upon your Plain all the three Circles required, *viz.* the

Horizon, *Meridian*, and the *Equinoctial*; by which may be found the three Requiſites belonging to this Plain. For,

1. *To find the Height of the Pole above the Plain, repreſented in the Scheme by the Line* P B. Lay a Ruler to G, where the *Equinoctial* cuts the Plain, and to P the Pole of the World, the Ruler will cut the Plain on the oppoſite Side in the Point *v*. So the Diſtance from B to *v*, meaſured upon the Line of Chords, will be found to contain 34 deg. 33 min. the Height of the Pole above the Plain.
2. *To find the Diſtance of the Subſtile from the Meridian, repreſented in the Scheme by the Arches* Z B, or N D. Take in your Compaſſes the Diſtance Z B, or N D, and you ſhall find either of them equal to 18 deg. 8 min. and ſuch is the Diſtance of the Subſtile from the Meridian.
3. *To find the Plain's Difference of Longitude, repreſented in the Scheme by the Angle* Æ P K. Lay a Ruler from P to Æ, it will cut the Plain in *x*, ſo the Diſtance between D and *x*, meaſured upon the Line of Chords, will be 30 deg. And ſuch is the Plain's Difference of Longitude.

Laſtly, Theſe Requiſites being obtain'd, we come to the drawing of the Hours; to effect which, lay a Ruler to P, the Pole of the World, and Æ, the Interſection of the *Equinoctial* with the *Meridian*, and it will cut the Plain in the Point *x*. —— At this Point *x* begin to divide the Semicircle L *x* G, into 12 equal Parts, at the Points ⊙ ⊙ ⊙, *&c.* Then laying a Ruler to Q, and every of theſe Points ⊙ ⊙ ⊙, *&c.* it will cut the Equinoctial Circle, dividing that into

12 equal Parts in the Points * * * *, *&c.* —— Again, A Ruler laid to P, and every of theſe unequal Parts * * * *, *&c.* will divide the Plain into 12 unequal Parts in the Points I I I I, *&c.* —— Lay a Ruler to Q, and every of theſe Points I I I, *&c.* drawing Lines by the Side thereof and they ſhall be the true Hour-lines proper to ſuch a declining *Plain.*

Thus have you finiſhed the Hour-lines, the Subſtilar-line, (or the Line upon which the Stile muſt ſtand) is the Line Q D, falling (in this *Dial*) juſt upon the Hour-line of 2 in the Afternoon, becauſe the *Plain* declined Weſtward. The Angle of the *Stile* is D Q R, containing 34 deg. 33 min. and muſt be either of *Plate* or *Wire* brought to ſuch an Angle, and muſt ſtand perpendicular to the *Plain*, and directly over the *Subſtilar* Q D.

Now have you finiſhed your *Dial*, and in ſo doing you have in this one made four *Dials*, *viz.*

A { South declining Weſt
South declining Eaſt *d.* *m.*
North declining Weſt 24 20
North declining Eaſt }

Only placing of the Numbers of the Hours and the Stile reſpectively upon each *Plain*. For in the South-weſt *Plain*, which we have now deſcribed, the *Stile* ſtands upon the Hour-line of 2 in the Afternoon; in the South-Eaſt declining as much, it will ſtand upon the Hour-line of 10 before Noon. And ſo all the Morning Hours of the Weſt Decliner, will be the Afternoon Hours of the Eaſt Decliner; and the Afternoon Hours of the Weſt Decliner, will be the Morning Hours of the Eaſt Decliner: And ſo the South Decliner will

The four upright Declining Dials. Plate 3. *Fig*. 4.

will produce the North-weſt Decliner; and the South-weſt Decliner, the North-eaſt Decliner, by only extending the *Hour-lines*, *Stile*, and *Subſtile* quite through the Center. And that there may yet remain no Doubt, I have drawn all the four *Dials* in one, by which you may plainly ſee that there is no Difference between them, but what hath been already intimated. Only before I leave them, I will, (becauſe theſe Dials are moſt in uſe) give you one other Example of an upright declining *Plain*, which by Reaſon of its great Declination from the *Prime Vertical*, or its *Poles* great Deviation from the Meridian, cauſeth the *Pole* to have but ſmall Elevation, wherefore the *Dial* (as all ſuch like) muſt be drawn without a Center, by the Directions following.

CHAP. VIII.

How to draw the Hour-lines upon Upright far Declining Plains, which by Reaſon of the ſmall Elevation, which the Pole hath over ſuch Plains, the Hours (if they be drawn from a Center) cannot be of any competent Diſtance one from another.

THOSE *Plains* which lie near to the Meridian *Circle*, and whoſe *Poles* (conſequently) near the *Prime Vertical Circle*, or Azimuth of Eaſt or Weſt; the *Pole* hath but ſmall Elevation above ſuch *Plains*, ſo that the Hour-lines (eſpecially thoſe of them which fall near to the *Subſtile*) from the Center, cannot be drawn at any competent Diſtance, without a large Extention of them. To remedy which Inconvenience, you may draw the Hour-lines for ſuch a *Plain* at a convenient Diſtance, and in a little Room, without any Regard had to the Center. But before you proceed to draw the *Dial*, you muſt firſt find the three Requiſites mentioned in the laſt Chapter, *viz.*

1. *The Height of the Pole above the Plain.*
2. *The Diſtance of the Subſtile from the Meridian.*
3. *The Plain's Difference of Longitude.*

Example of an Upright South Plain, declining Eaſtward 80 *deg. in the Latitude of* London 51 *deg.* 32 *min.*

To find theſe Requiſites.

Plate 3. *Fig.* 5.

Firſt, Draw the Circle Z H N O, croſſing it with the Diameters Z N, the Perpendicular, and H O, the Horizontal Line of the *Plain*.

Secondly, Becauſe the *Plain* declineth 80 deg. Eaſtward, ſet 80 deg. from N to *a*, and from H to *b*.

Thirdly, Lay a Ruler to Z and *a*, it will cut the Horizon in S, the South Point thereof, and a Ruler laid to Z and *b*, will cut the Horizon in E, the Eaſt Point thereof.

Fourthly, Having the three Points Z S and N, through them draw the Meridian Z S N, whoſe Center (by any of the Ways before taught) will be found to be at *m*.

Fifthly, Out of your Line of Chords take 51 deg. 32 min. the Latitude, and ſet them from O to *c*, and from N to *d*. Then laying a Ruler from E to *c*, it will cut the Meridian in P, the *Pole* of the World; through which Point P and Q, the Center of the Plain, draw the right Line P Q B, for the Axis of the World. Alſo the Ruler laid from E to *d*, will cut the Meridian in Æ, ſo is Æ one Point in the Meridian, through which the Equinoctial muſt paſs, and R is another Point in the Meridian (extended) without the Circle, and a third Point is E, the Eaſt Point of the Horizon. Now foraſmuch as theſe three Points R E Æ, through which the Equinoctial is to be drawn, are almoſt in a ſtrait Line, ſo that the Center of it will be at a very great Diſtance, we will forbear deſcribing of that Circle, and content ourſelves that we have found the Points R E Æ, through which it ſhould paſs; becauſe we ſhall draw the Hour-lines in this and the like Caſes by other Means, and therefore I ſhall proceed to find the other Requiſites. And,

1. *To find the Height of the Pole above the Plain, repreſented by P C.*——Take 90 deg. of your Line of Chords, and ſet them from *c* to *e*, a Ruler laid to *e* and P, will cut the *Plain* in *o*, ſo is *o* C the Height of the *Pole* (or *Stile*) above the *Plain*, *viz.* 6 deg. 12 min.
2. *To find the Diſtance of the Subſtile from the Meridian, repreſented by* B *N or* Z c.—Take the Diſtance B N or Z c (which is equal thereto) in your Compaſſes, and meaſure it upon your Line of Chords, ſo you ſhall find it

An Erect South Plain Declining Eaſtward 80 *deg. Plate* 4. *Fig.* 1.

it to contain 38 deg. 4 min. which is the Diſtance of the *Subſtile* from the Meridian.

3. *To find the Plain's Difference of Longitude, repreſented by the Angle Q P Æ.* —— Lay a Ruler upon P and Æ, it will cut the *Plain* in *g*, the Diſtance *g* B, meaſured upon the Line of Chords, will contain 82 deg. 8 min. the *Plain's* Difference of Longitude.

THESE three Requiſites being thus found, I will now proceed to draw the *Dial*, without any Regard had to the Center.

How to draw the Hour-lines upon the Plain.

Firſt, Draw a right Line A B, for the perpendicular Line of your *Plain*, and upon A as a Center, with 60 deg. or the Radius of your Chord, deſcribe an obſcure Arch of a Circle C D E, and thereon from C to D, ſet 38 deg. 4 min. the *Subſtile*'s Diſtance from the Meridian before found, and draw the Line A D for the *Subſtile*, quite thro' the *Plain*.

Secondly, Take 6 deg. 12 min. the Height of the *Pole* above the *Plain* from your Chord, and ſet them upon the ſame Arch from D to E, and draw the Line A E for the *Stile*.

Thirdly, Foraſmuch as the *Stile* A E in this Caſe is but of ſmall Elevation, *viz.* but 6 deg. 12 min. Draw the Line G H parallel to A E, at ſuch convenient Diſtance as you ſhall think fit, for your new (or augmented) *Stile* to ſtand from your *Subſtile* A D.

Fourthly, Aſſume any two Points in the *Subſtile* A D, as R and S, and through theſe two Points draw two infinite right Lines, both of them at right

Angles

ngles to the *Subſtilar* Line A D, as the Lines Z Z nd XX.

Fifthly, From the Point R, take with your Com-aſſes the leaſt Diſtance to the new augmented *Stile* G H, and ſet that Diſtance upon the *Subſtilar* ine, from R to K: Alſo from the Point S, take he leaſt Diſtance to the new Stile G H, and ſet hat Diſtance alſo upon the *Subſtilar* Line from S o L.

Sixthly, Upon the two Points K and L (as upon wo Centers) with 60 deg. or the Radius of the ine of Chords, deſcribe the Portions of *Circles*, nd in either of them ſet off 82 deg. 8 min. the *lain*'s Difference of Longitude, as from *S* to M, nd from R to M, both on the ſame Side of the *ubſtilar Line*, on which the perpendicular Line of he Plain A B was drawn.

Seventhly, Divide either of the Semicircles laſt rawn into 12 equal Parts, at the Points ☉ ☉ ☉, *&c.* beginning this Diviſion in either of them, at he Point M.

Eighthly, Lay a Ruler to the Point L, and every f the Diviſions ☉ ☉ ☉, *&c.* and the Ruler will ut the Contingent or *Equinoctial* Line X X, in he Points * * * *&c.* Alſo a Ruler laid to K, and ach of the Points ☉ ☉ ☉, *&c.* will cut the o-her Contingent Z Z, in the Points * * * *&c.*

Laſtly, Lines drawn from the Point * in one ontingent Line, to the Point * in the other con-ngent Line, each to his Correſpondent (which he *Subſtilar Line* will direct you how to do) thoſe ines ſhall be the true Hour-lines belonging to ſuch *Declining Plain*, and be drawn as in the Figure ou ſee done, at a competent Diſtance one from nother, without any Relation at all had to the enter of the *Dial*.

Thus have you finiſhed your *Dial*, and in the making of this, you have made a South declining Weſt 80 deg. alſo; for if you turn the Paper, and look through it, it will on the Backſide be a South declining Weſt 80 deg. only the Forenoon Hours in this, muſt be the Afternoon Hours in that: Nay, rather, you have in this one Dial made four, *viz.* a North declining either Eaſt or Weſt: if you well obſerve what was ſaid and done in the laſt Chapter.

> And thus have I done with all *Upright* or *Erect Plains*, either *Direct* or *Declining*. I ſhall now proceed to ſhew you how to inſcribe Hour-lines upon ſuch *Plains* as are not upright but *recline* from the *Zenith*, and of them there are ſuch as are *Direct*, and ſuch as do decline.

III. *Of Reclining Plains.*

CHAP. IX.

As in upright *Plains* there were two Varieties, *viz. Erect Direct*, and *Erect Declining*; ſo are there of *Reclining Plains* alſo. For ſuch *Reclining Plains* as do directly behold either the true *Eaſt*, *Weſt*, *North*, or *South* Points of the Heavens, that is, whoſe Poles lie either in the *Meridian*, or *Prime Vertical Circle* of the Place, are called *Direct Reclining Plains.*

Again, Thoſe *Reclining Plains* which do not directly lie in, or their Poles be not in the prime Vertical or Meridian Circles of the Place, but deviate therefrom, are called *Declining Reclining Plains*. Of both which Sorts I ſhall give you an Account, and the manner of inſcribing Hour-lines upon them, for in theſe Plains there is far more Variety, than there was in Upright or Erect Plains.

Of Direct Reclining Plains, &c.

I. *Of* Eaſt *and* Weſt *Recliners.*

CHAP. X.

How to draw the Hour-lines upon a Direct Eaſt or Weſt Reclining or Inclining Plain.

AS in upright declining Dials, two Things muſt be given, and three Things muſt be ound, before the Hour-lines can be drawn; ſo n theſe direct reclining Plains, two Things muſt lſo be given, and three muſt be found, before he Dial can be made.

The Things that muſt be given, are

1. The Latitude of the Place.
2. The Reclination of the Plain.

THE Reclination of a Plain, (as hath been beore declared) is the Arch of an Azimuth or Verical Circle, intercepted between the Zenith of he Place, and the Reclining Plain.

Example, Of an Eaſt or Weſt Plain, Reclining 35 *deg. in the Latitude of* London, 51 *deg.* 32 *min.*

		d.	*m.*
Given	Latitude of the Place	51	32
	Reclination of the Plain	35	00

Required
- The Height of the Pole above the Plain.
- The Diſtance of the Subſtile from the Meridian.
- The Plain's Difference of Longitude.

Firſt, Draw the Circle N E S R, repreſenting the Reclining Plain, and croſs it with the two Diameters N Q S, the Horizontal-line of the Plain, and the Hour-line of 12 a Clock, and E Q R for the prime Vertical Circle.

Secondly, Becauſe the Plain reclines 35 deg. take 35 deg. out of your Line of Chords, and ſet them from *E* to *a*, and from N to *b*.

Thirdly, Lay a Ruler from S to *a*, and it will cut the prime Vertical Circle in Z, ſo is Z the Zenith of the Place —— Alſo a Ruler laid from S to *b*, will cut the ſame Vertical Circle in W, by which Point the Horizon of the Place muſt be drawn.

Eaſt and Weſt Inclining. Plate 4. *Fig.* 2.

Fourthly, The Points Z and W being found, you have three Points through which you muſt deſcribe the *Meridian*, *viz.* N Z and S; and as many alſo through which you muſt draw the *Horizon*, namely, N W and S. The Centers of both which Circles will fall in the Line E Q R, (extended if need be) and the Manner how to find them, hath been often enough already taught.

Fifthly, Becauſe the Latitude of the Place is 51 deg. 32 min. Take 51 deg. 32 min. from your Line of Chords, and ſet them upon your Plain from S to *c*. Then lay a Ruler upon W, the Weſt-point of the *Horizon*, and the Point *c*, the Ruler will croſs the *Meridian* Circle in P the Pole of the World; through which Point P and Q, the Center, (or Pole of the *Plain*) draw the right Line P Q, which ſhall be the Subſtilar Line of your Dial.

Sixthly, Take 90 deg. of your Line of Chords, and ſet them upon the Circle of your *Plain* from *c* to *d*, then lay a Ruler from W to *d*, and it will cut the *Meridian Circle* in Æ, ſo is Æ one Point in the *Meridian*, through which the Æquinoctial Circle muſt be drawn, and W the Weſt Point of he Horizon is another; ſo have you two Points within the Circle, through which you muſt deſcribe the *Æquinoctial Circle*, whoſe Center will be in the Line P Q, the Axis of the World, (extended if need be) the manner how to find it hath already been taught ſeveral Ways.

Having thus projected the Meridian, Horizon, and Equinoctial, you may find the three Requiites, as followeth.

1. *To find the Height of the Pole above the Plain* P *k*, Lay a Ruler to *g* and P, it will cut the *Plain* on the Oppoſite ſide in *h*; ſo *k h* meaſured upon the Chords, will be 26 deg. 41 min. *The Height of the Pole above the Plain.*
2. *To find the Diſtance of the Subſtile from the Meridian S k*, Take *S k* in your Compaſſes, and meaſure it upon the Chord, it will be found

found 45 deg. 52 min. *The Diſtance of the Subſtile from the Meridian.*

3. *To find the* Plain's *Difference of Longitude*, Æ P Q, A Ruler laid from P to Æ, will cut the Plain in *e*, the Diſtance from O the Subſtile, to *e* will contain 66 deg. 27 min. of the Chord, which is *The* Plain'*s Difference of Longitude.*

These Requiſites being obtained, you may proceed to find the Hour Diſtances upon the Plain in this Manner.

Seventhly, Lay a Ruler to P the Pole, and Æ the Interſection of the Meridian with the Equinoctial, and it will cut the Plain in *e*. At *e* begin to divide the Semicircle into 12 equal Parts, at the Points ⊙ ⊙ ⊙, *&c.*

Eighthly, Lay a Ruler to Q, and the ſeveral Points ⊙ ⊙ ⊙, *&c.* and it will cut the *Equinoctial Circle* in the Points * * *, *&c.* dividing that into 12 unequal Parts.

Ninthly, Lay a Ruler to P, and the ſeveral Points * * *, *&c.* and it will cut the Plain in the Points I I I, *&c.*

Laſtly, If from the Center Q, you draw right Lines through the Points I I I, *&c.* they ſhall be the true Hour-lines belonging to the *Reclining* Plain.

And thus have you finiſhed your *Dial*, and alſo in it 4 *Dials*: For the *Dial* as it here ſtands in the Scheme, is properly an Eaſt and Weſt *Incliner*, but being turned upſide down, as you ſee the Hours numbred, and the Word *Zenith* ſtanding upwards, it is an Eaſt *Recliner*; and if the Hour-lines be turned, (or ſuppoſed to ſtand) on the right Hand of the prime Vertical Line E Q R, as in this Scheme they do on the left Hand, and the

Hours of 4, 5, 6, *&c.* in the Morning changed to 8, 7, 6, in the Evening, the Plain is then a Weſt *Recliner.* And if the Hour-lines be drawn through the Center of either of them, the Plains then become Eaſt and Weſt *Incliners*; the Hours and Subſtile in all retaining the ſame Place, only the Denominations of the Hours changed, *&c.* you muſt remember, that in all Eaſt and Weſt *Recliners*, the North Pole is elevated, and in all *Incliners* (oppoſite to them) the South Pole.

* * *

II. *Of South Recliners.*

CHAP. XI.

How to draw the Hour-lines upon Direct South Reclining or Inclining Plains.

IN the Eaſt and Weſt Reclining and Inclining Plains, before deſcribed, the Meridian, or 12 a Clock Hour-line did lie in the Horizontal-line of the Plain, and the Poles thereof in the prime Vertical Circle. So (on the contrary) in theſe South and North Reclining and Inclining Plains, their *Horizontal Line* lieth in the prime Vertical Circle, or Hour of 6, and their Poles in the Meridian, and from hence they receive their Denomination.

Of theſe Direct Reclining Plains there are ſix Varieties, *viz.* Three of South Recliners, and as many of North Recliners. For,

1. The South Plain may recline, ſo as it may juſt fall in the Axis of the World, and ſo paſs through the Poles of the World, and then it is

called an *Equinoctial* Plain, becauſe the Poles thereof lie in the *Equinoctial Circle*, and neither of the Poles have any Elevation above it; wherefore the Hour-lines muſt be all parallel one to the other, and all of them to the Axis of the World, and the *Dial* muſt be drawn as the Erect Direct Eaſt or Weſt *Dials* were. Only, whereas the Stile ſtood upon the Hour-line of 6 in the Eaſt and Weſt, in theſe Plains it muſt ſtand upon the Hour-line of 12, and be of equal Height with the Diſtance between the Hours of 12 and 9, or 12 and 3, which are equidiſtant from the Meridian.

2. Or *Secondly*, The South Plain may ſo recline, that it may fall between the Zenith and the North Pole, and then is the South Pole elevated above ſuch a Plain. Or,

3. The South Plain may ſo recline, that it may fall between the Horizon and the North Pole, and then is the North Pole elevated.

Examples of theſe three Varieties of South Reclining Plains do here follow.

* * *

The Firſt Variety.

CHAP. XII.

How to draw the Hour-lines upon an Equinoctial Plain, or a Plain reclining juſt to the Pole.

FIRST, Draw the right Line A B, for the *Horizontal Line* of the Plain, and croſs it about the Middle thereof at right Angles, with the Line 12 Q 12 for the Meridian and Hour-line of 12.

Secondly, Upon the Line 12 Q 12, either above or below Q, aſſume any Point, as S, and ſetting one Foot of your Compaſſes therein, (it being opened to the Radius of your Line of Chords) deſcribe the Semicircle C D E, which divide into 12 equal Parts, beginning at D.

Thirdly, Lay a Ruler to S, and the ſeveral Points ⊙ ⊙ ⊙, &c. and it will croſs the Equinoctial Line A B, in the Points * * *, &c.

Laſtly, Through theſe Points * * *, &c. draw right Lines all parallel to the Line 12 Q 12, and ſo is your Dial finiſhed.

A Direct Equinoctial Dial. Plate 3. *Fig.* 6.

THE Stile may be either a ſtrait Pin, of the Length of the Line Q S, ſet perpendicular to the *Plain* upon the Point Q; the Shadow of the Top thereof only giving the Hour. Or it may be a Plate of the Breadth of the Diſtance that is between the Hour-lines of 12 and 3, or 12 and 9, and then will the Shadow of the upper Edge thereof give the Hour of the Day.

The Second Variety.

CHAP. XIII.

How to draw the Hour-lines upon a Direct South Reclining Plain, which falls between the Zenith and the Pole.

Let the Example be of a *South Plain Reclining* 25 deg. in the Latitude of *London*, 51 deg. 32 min.

FIRST, Draw the Circle W D E R, croſs it with the two Diameters D R, for the Meridian and Hour-line of 12, and W E, for the Horizontal Line of the *Plain*, and Hour-line of Six.

Secondly, Take 25 deg. the *Plain*'s Reclination, out of your Line of Chords, and ſet that Diſtance from D to *a*, and from E to *b*.

Thirdly, A Ruler laid from W to *a*, will give Z the Zenith of the Place; and a Ruler laid from W to *b*, will give S the South point of the Horizon; both which Circles W Z E, the *prime Vertical* and W R E the *Horizon*, may be drawn, as hath often enough already been ſhewn, their Centers being always in the Meridian Line D Q R, extended, if need require.

Plate 4. *Fig.* 3.

Fourthly, Becauſe the *Pole* of the World is always diſtant from the *Zenith*, the Complement of the Latitude of the Place, *viz.* here at *London*,

p. 64.

Fig. 1

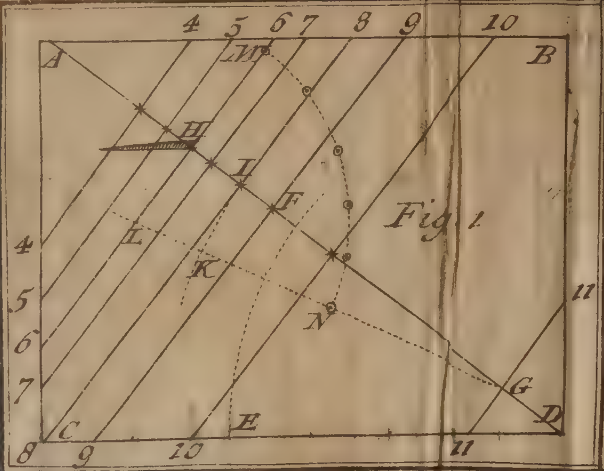


Fig. 2

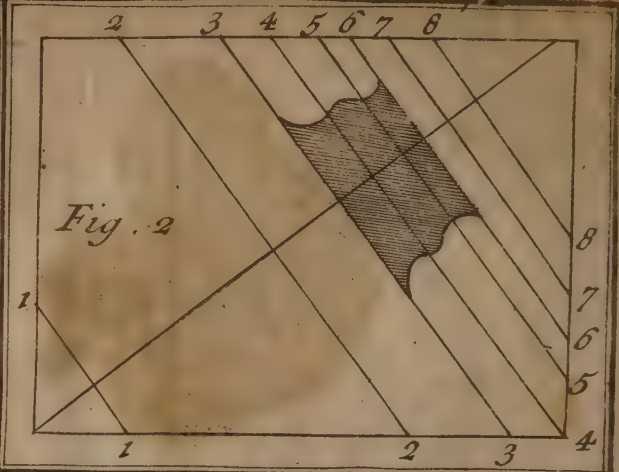
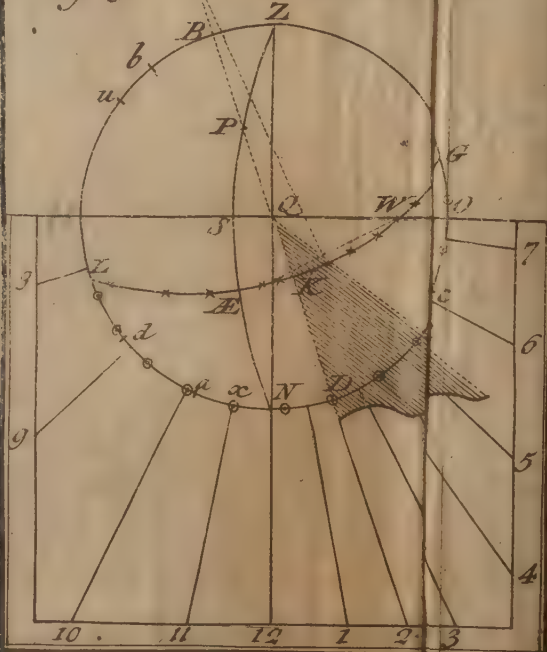


Plate 3.

Fig. 3



North Declining East, and South Declining West 24°. 20′	North Declining West, and South Declining East 24°. 20′

Fig. 4

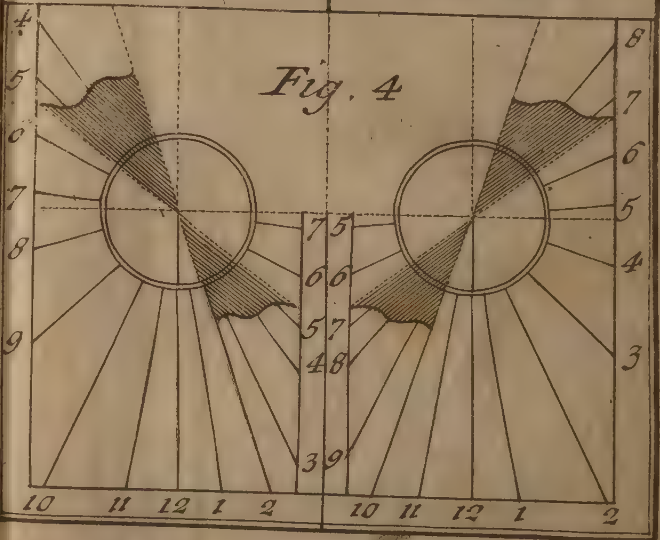


Fig. 5

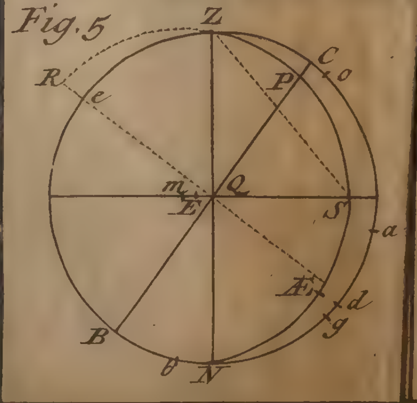
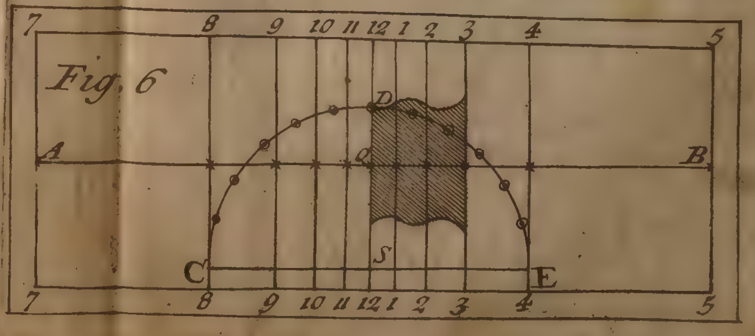


Fig. 6



don, 38 deg. 28 min. Take therefore 38 deg. 28 min. out of your Line of Chords, and ſet them upon your Plain from *a*, (the Point which found the Zenith) to C.

Fifthly, Lay a Ruler from W to C, and it will cut the Meridian D Q R, (being thus extended) in *P*, ſo is *P* the North Pole of the World, and becauſe it falleth without the *Plain*, it is evident by the Scheme, that this reclining *Plain* paſſeth hrough the Meridian, between the Zenith and he Pole. And again, becauſe the North Pole P falleth without the *Plain*, it alſo demonſtrates, hat the South Pole muſt be elevated above this Plain. Wherefore,

Sixthly, To find the Point of the South Pole upon the Meridian Line D Q R, do thus. Becauſe the two Poles are 180 deg. diſtant from each other; *viz.* two Quadrants, or twice 90 deg. Take therefore 90 deg. out of your Line of Chords, and ſet them twice upon your *Plain* rom C, *viz.* firſt from C to *e*, and then from *e* o *n*, ſo ſhall the 180 deg. end in *n*: And a Ruler being laid from W to *n*, ſhall croſs the Meridian in A, the South Pole; ſo is the South Pole A elevated above the Reclining Plain, the Quantity of A R, which is equal to the Arch R , which meaſured upon the Line of Chords, will be found 13 deg. 28 min.

Seventhly, Lay a Ruler from W to *e*, and it will cut the Meridian in Æ, ſo is Æ that point n the Meridian, through which the Equinoctial uſt paſs. As alſo through the Points E and W, e Eaſt and Weſt Points of the Horizon.

Eighthly, For the Hour-lines, they are to be rawn in all Reſpects as the Hour-lines were upon the upright South Plain, without any Alteraon, only there the Stile was elevated according

ing to the Complement of the Latitude 38 deg. 28 min. here it muſt be elevated only 13 deg. 28 min. as in the Scheme. The manner how the Hour-lines are to be put on, I ſhall only repeat; but I ſhall forbear drawing them, leaving that to your own Practice, in regard there is no Alteration at all from the Erect Direct South Plain. Wherefore divide the Semicircle of your Plain W R E into 12 equal Parts, (beginning at R, and ſo 6 equal Parts on either Side of the Meridian D Q R.) Then lay a Ruler to Q, and every of thoſe 12 Diviſions, it will divide the Equinoctial into 12 unequal Parts. A Ruler laid from P to every of thoſe unequal Parts in the Equinoctial, will divide the Plain into 12 other unequal Parts, through which laſt 12 unequal Parts, and the Center Q, if you draw right Lines, they ſhall be the true Hour-lines proper for the *Plain.*

> AND here by the Way note, For that the *Equinoctial Circle* in this Scheme is a very oblique Arch, the Center of it will be very remote, and the Hour-ſpaces upon it (as alſo upon the *Plain)* will be very cloſe together in theſe ſmall Draughts, which is occaſioned by the ſmall Elevation that the South *Pole* hath above this Plain, *viz.* but 13 deg. 28 min. which you might find without drawing of the Scheme, by ſubtracting 25 deg. the *Plain*'s Declination, repreſented in the Scheme by the Line (or Circle) D Z, from Z P, the Complement of the Latitude of the Place. And therefore, foreſeeing that the Pole hath but ſmall Elevation above the Plain, and alſo what *Pole*, whether North or South that is elevated: The better

Way will be to augment the Stile, and to draw the *Dial* according to theſe following Directions.

How to draw the Hour-lines upon the Plain.

In the Scheme following, draw, *Firſt*, The right Line W Q E, for the *Horizontal*, and *perpendicular* thereunto, the Line S Q R, for the Meridian and Hour-line of 12, which extend above the Horizontal Line to S.

Secondly, Upon S as a Center, with 60 deg. of your Chord, deſcribe a ſmall Arch of a Circle, and upon it ſet 13 deg. 28 min. the Height of the Pole above the Plain from A to B, and draw the Line S B for the Stile.

South Reclining 25 deg. Plate 4. *Fig.* 4.

Thirdly, At any convenient Diſtance anſwerable to the Largeneſs of your Plain, draw a Line parallel to W E, as the Line C D F.

Fourthly, Set one Foot of your Compaſſes in D, and with the other take the neareſt Diſtance to the Stile S B, which Diſtance ſet upon the Meridian from D to H.

Fifthly, Upon the Point H, (your Compaſſes opened to 60 deg. of your Line of Chords) deſcribe the Semicircle K Q L, which divide into 12 equal Parts in the Points ⊙ ⊙ ⊙, *&c.*

Sixthly, Lay a Ruler unto H, and upon every of the Points ⊙ ⊙ ⊙, *&c.* and it ſhall cut the Equinoctial Line CDF, in the Points * * *, *&c.* through which the Hour-lines muſt paſs: Wherefore, if from the Center S, and through the ſeveral Points * * *, *&c.* in the Line C D F, you draw ſtrait Lines, bounding them between any two Lines as W E, and M N, they ſhall be the true Hour-lines. Or,

Seventhly, If you draw another Tangent Line, and deſcribe another Semicircle, and divide it, and the other Line, as you did the former, ſo ſhall the Lines drawn through the reſpective Points * * *, *&c.* in either of the Equinoctial (or Tangent Lines) be the true Hour-lines belonging to the Plain, without any Regard had to the Center at all, as you before did in Upright far Decliners.

* * *

The Third Variety.

CHAP. XIV.

How to draw the Hour-lines *upon a* Direct South Reclining Plain, *which paſſeth between the* Pole *and the* Horizon.

Let the Example be of a South Plain, Reclining 55 deg. in the Latitude of *London*, 51 deg. 32 min.

F*IRST*, Draw the Circle W N E R, for your Reclining-plain, croſs it with two Diameters N Q R, the Meridian, and W Q E, the Horizontal-line of the *Plain*.

Secondly, Take 55 deg. the *Plain*'s Reclination out of your Line of Chords, and ſet that Diſtance from N to *a*, and from E to *b*.

Plate 4. Fig. 5.

Thirdly, Lay a Ruler from W to *a*, it will cut the Meridian in Z, ſo is Z the *Zenith* of the Place, thro which, and the Points W and E, draw the prime Vertical Circle W Z E.

Fourthly, Lay a Ruler from W to B, and it will cut the Meridian in S, the South Point of the *Horizon*, through which and the Points W and E, the Horizon of the Place W S E muſt be drawn.

Fifthly, The Pole being diſtant from the *Zenith* of the Place 38 deg. 28 min. equal to the Complement of the Latitude, ſet 38 deg. 28 min. from *a* to C, and a Ruler laid from W to C, ſhall cut the Meridian in *P*, the Pole of the World, and 90 deg. of your Line of Chords being ſet from C to *n*, and a Ruler laid from W to *n*, ſhall cut the Meridian in Æ through which and the Points W and E muſt the Equinoctial Circle be deſcribed: The Center whereof, as alſo of the Horizon and prime Vertical Circles are all in the Meridian N Q R, extended where need requires; and how theſe Centers are to be found, is ſhewed already.

Sixthly, For the drawing of the Hour-lines, they muſt be drawn as in the Erect Direct South Plain, or as was directed in the laſt Plain, and ſo I ſhall ſay no more of them in this place, only take Notice, that the North Pole is elevated above this Plain, the Quantity of the Arch N C, which is 16 deg. 32 min.

THESE are the three Varieties of South Direct Reclining Plains, and in the making of theſe you have alſo made the oppoſite Incliners as much; for each Plain hath two Faces, the one open to the *Zenith*, and the other to the *Nadir* of the Place.

III. *Of North Direct Recliners.*

CHAP. XV.

How to draw the Hour-lines *upon a* Direct North Reclining *Plain.*

AS in *South Reclining Plains* there were three Varieties, ſo alſo are there as many in the *North Recliners.* For,

1. THE North Plain may ſo recline, that it may paſs through the Meridian, juſt at the Interſection of the Meridian with the Equinoctial, the *Plain* it ſelf lying in the Equinoctial Circle, and the Poles thereof in the Poles of the World, and ſo it is called, *A Polar-plain.* Or.

2. THE *Plain* may ſo recline, that it may cut the Meridian between the *Zenith* and the *Equinoctial.* Or,

3. IT may recline ſo far, as to cut the Meridian between the Equinoctial and the Horizon.

Examples of theſe three Varieties of North Reclining Plains follow.

The

Plate 4.

Fig. 1.

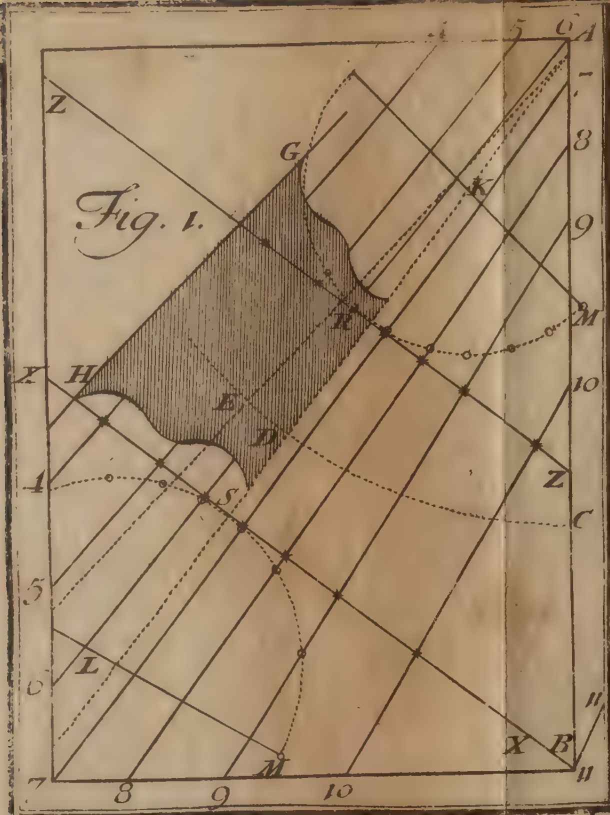


Fig. 2.

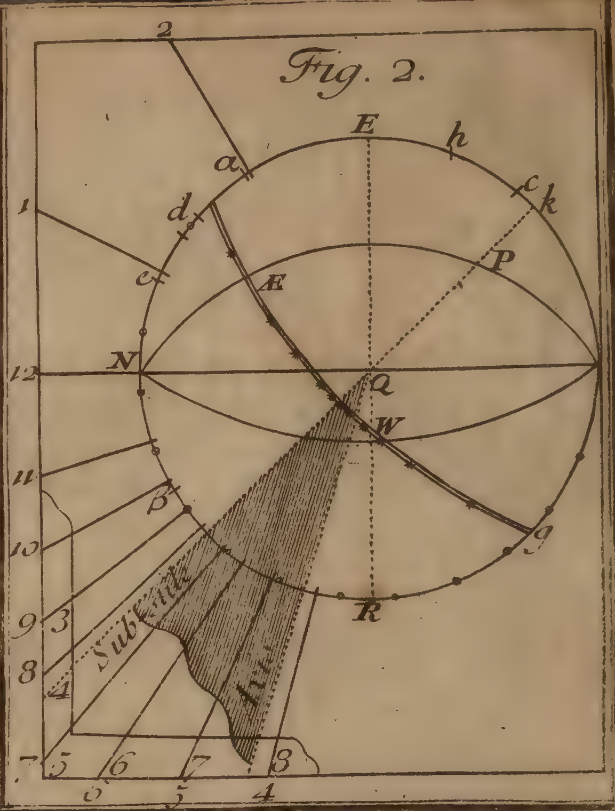


Fig. 3

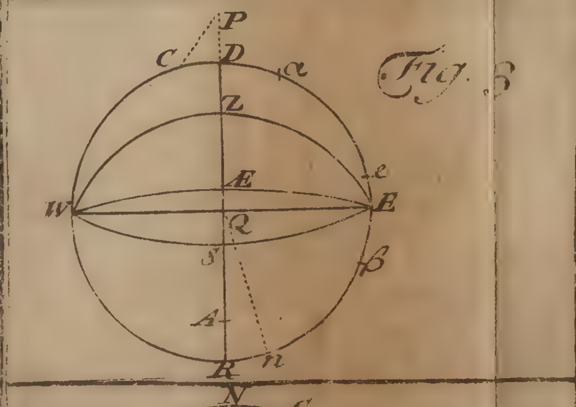


Fig. 5

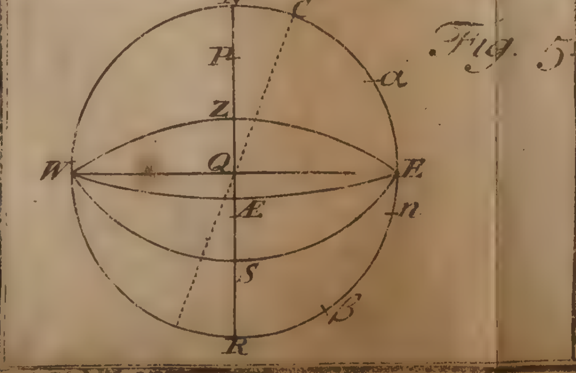
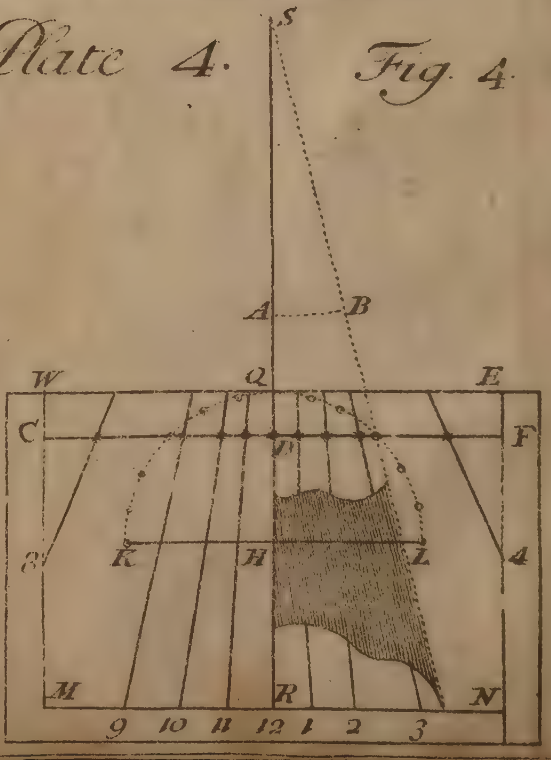


Fig. 4



The Firſt Variety.

CHAP. XVI.

How to draw the Hour-lines upon a Direct Polar-plain, *which reclineth juſt to the* Equinoctial.

Example of a North-plain, Reclining 51 deg. 32 min. equal to the Latitude of the place, *viz.* London.

FIRST, Deſcribe the Circle E Æ W R, for your *Plain*, croſs it with the Diameters Æ Q R, for the Meridian, and W Q E for the prime Vertical Circle.

Secondly, Set 51 deg. 32 min. the Reclination of the *Plain*, (which in this Example is alſo equal to the Latitude of the Place) from Æ to *a*, and alſo from W to *b*.

Thirdly, A Ruler laid from E to *a*, will cut the North part of the Meridian in Z the *Zenith* of the place, and being laid from E to *b*, it will cut the Meridian in N, ſo is N the North point of the *Horizon*.

Fourthly, Through the Points W, Z and E, (by former Direction) draw the prime Vertical Circle, or Azimuth of Eaſt or Weſt, W Z E. And alſo through W, N and E, draw the Horizontal Circle W N E.

Fifthly, Becauſe the Pole of the World is always removed from the Zenith of the Place, ſo much as is the Complement of the Latitude (in this Example 38 deg. 28 min.) Set 38 deg. 28

min. from *a*, (the Point in the *Plain*, which found the Zenith Point Z,) Northward of the Zenith, and the Compaſs-point will fall in W, the Weſt-point of the Horizon; ſo that if a Ruler were laid from W to E, it would cut the Meridian in Q, for the Pole of the World, which is already the Center of the Plain, ſo that the Pole of the World, and the Pole of the Plain, fall both in one Point, and the Pole Q is elevated above the Plain 90 deg. *viz.* the Quantity of the Meridian Line Æ Q, or rather the Arch Æ W, which is the Meaſure thereof.

A Direct Polar North Dial. Plate 5. Fig. 1.

Sixthly, To draw the Hour-lines upon this Plain, it is eaſieſt of all others, for if you divide the Semicircle E R W, into 12 equal Parts in the Points ⊙ ⊙ ⊙, &c. and through thoſe Points draw ſtrait Lines from the Center Q, they ſhall be the true Hour-lines belonging to this *Polar-plain.*

AND this Plain, by Reaſon of its North Reclination, is, in Summer, capable of receiving all the Hours from Sun-riſing to Sun-ſetting, and therefore the Hour-lines of 4 and 5 in the Morning, and of 7 and 8 at Night, muſt be drawn through the Center, as you did in the Vertical or Horizontal Dial, and as you ſee here done in this Figure.

THE Stile of this Dial muſt be a ſtrait Pin or Wire, ſet perpendicular upon the Plain, from the Center Q, and of any Length. And this for the firſt Variety of North Recliners.

THE South Inclining Plain oppoſite to this, is directly the ſame, only the Forenoon Hours in this muſt be the Afternoon Hours in that, and the Hours of 4 and 5 in the Morning, and of 7 and 8 in the Evening, muſt be omitted.

The

The Second Variety.

CHAP. XVII.

How to draw the Hour-lines upon a North Reclining Plain, *which interſects the Meridian between the* Zenith *and the* Equinoctial.

Let the Example be of a North Plain, Reclining 25 deg.

FIRST, Draw the Circle E S W R, repreſenting your North *Reclining Plain*, and croſs it with the two Diameters S Q R, the Meridian of the Place, and E Q W, the *Horizontal* Line of the Place.

Secondly, Set the *Reclination* of the *Plain* 25 deg. from S to *a*, and from W to *b*.

Thirdly, Lay a Ruler from E to *a*, it will cut the Meridian in Z the Zenith. And a Ruler laid from E to *b*, will cut the Meridian in N the North Point of the Horizon: So have you three Points E Z and W, whereby to draw the prime Vertical Circle E Z W, and three Points alſo, *viz.* E N and W, whereby to draw the Horizon E N W.

Fourthly, Becauſe the Equinoctial is always 90 deg. diſtant from either of the *Poles*, ſet 90 deg. upon your *Plain*, from *c* to *d*. Then laying a Ruler to E and *d*, it will cut the Meridian in Æ, ſo is Æ the Point of the Interſection of the Equinoctial, with the North part of the Meridian; wherefore through the Points E Æ W, deſcribe the Equinoctial Circle; the Center whereof, as alſo of the Horizon, and prime Vertical Circle, will fall in the Meridian S Q R, extended where need requires.

Plate 5. Fig. 2.

Fifthly, The *Horizon*, *Equinoctial*, and *Pole* being thus ſeated in their true Poſitions upon the *Plain*, the Thing required in this Dial, is, *The Height of the Pole above the Plain*, which may be found in this Manner. —— Lay a Ruler from E to P, and it will cut the Plain in *c*, the Diſtance S *c*, meaſured upon your Line of Chords, will contain 63 deg. 28 min. which is the Height of the *Pole* above the *Reclining Plain*.

Laſtly, For the drawing of the Hours, that is done the ſame Way as in the Erect Direct South *Plain*, only here the *Stile* muſt be elevated above the *Meridian Line* 63 deg. 28 min. whereas there it was only 38 deg. 28 min. the Complement of the Latitude. The North *Pole* is elevated above this *Plain*, and the Hours that the *Plain* is capable to receive, are 4, 5, 6, 7, 8 and 9 in the Morning, and 3, 4, 5, 6, 7 and 8 at Night.

THE Height of the *Pole* (or *Stile)* above this *Plain* may be found by adding the Complement of the Latitude 38 deg. 28 min. and 25 deg. the Reclination together, the Sum whereof is 63 deg. 28 min. the Height of the Stile, as before.

The Third Variety.

CHAP. XVIII.

How to draw the Hour-lines upon a Direct North Reclining Plain, which interſects the Meridian between the Equinoctial and the Horizon.

Let the Example be of a Direct North Plain, Reclining 70 deg. in the Latitude of *London*, 51 deg. 32 min. Plate 5. Fig. 3.

FIRST, Draw the Circle E S W R, repreſenting your North Reclining *Plain*, and croſs it with the two Diameters S Q R, for the Meridian of the Place, and with E Q W the Horizontal Line of the *Plain*.

Secondly, Set the Reclination of the *Plain* 70 deg. from S to *a*, and from W to *b*.

Thirdly, Lay a Ruler to E and *a*, it will cut the Meridian in Z the Zenith, through which, and the Points E and W, draw the prime Vertical Circle E Z W. —— Alſo, lay a Ruler from E to *b*, it will cut the Meridian in N, the Interſection of the Meridian with the North Part of the Horizon; now through the Points E N and W, deſcribe the Horizon of the Place E N W.

Fourthly, Foraſmuch as the Pole is diſtant from the Zenith of the Place 38 deg. 28 min. (equal to the Complement of the Latitude) ſet 38 deg. 28 min. from *a*, the Point which gave the Zenith Z to *c*, and lay a Ruler from *e* to *c*, ſo ſhall it croſs the Meridian in *P*, the Pole of the World.

Fifthly, Becauſe the Equinoctial is in all Places ſituate 90 deg. from either Pole. Take 90 deg. in your Compaſſes, and ſet them off from *c*, (the Point which gave the Pole *P*) both ways, to *e* above, and to *g* below. So a Ruler laid from E to *g*, will cut the Meridian (it being extended) in Æ, without the Plain, which ſhews that the North Part of the *Equinoctial Circle* lies below this *Plain*. Therefore lay a Ruler from E to *e*, and it will croſs the Meridian in Æ above: So is Æ the Point where the Meridian, and the South-point of the *Equinoctial* will interſect, and thro' that Point and the Points E and W, muſt the *Equinoctial* E Æ W, be drawn.

Sixthly, The *Horizon*, *Pole*, and *Equinoctial*, being thus projected, the Thing required in this Plain, is, *The Height of the Pole above it*, viz. P R, which may be found in this manner. —— Lay a Ruler from E to *P*, and it will cut the Plain in *c*, the Diſtance from R to *c* meaſured upon the Chord, will be 71 deg. 32 min. which is the Height of the Pole above this Reclining Plain.— Or the Height of the Pole above the Plain may be found, by adding the Plain's Reclination 70 deg. to 38 deg. 28 min. the Complement of the Latitude, the Sum whereof 108 deg. 28 min. which taken from 180 deg. the Remainder will be 71 deg. 32 min. as before.

Laſtly, For the drawing of the Hour-lines, they are done in all Reſpects as thoſe before in South Erect Plains, only in this make the Elevation of the Stile 71 deg. 32 min. as you find it by your Projection.

YOUR Hour-lines being drawn, erect the *Stile* 71 deg. 32. min. above the Meridian or Subſtile, letting it point up to the North Pole, becauſe that Pole above this Plain is ſo much elevated ;

and being this Plain is but 20 deg. raiſed above the Horizon, *viz*. the Complement of his *Reclination*, the Plain is capable to receive all the Hours from 4 in the Morning to 8 at Night, and therefore the Hours of 4 and 5 in the Morning, and 7 and 8 in the Evening, muſt be drawn through the Center, as was done in ~~the~~ *Vertical* or *Horizontal Dial*.

Plate 5. *Fig*. 3.

AND thus have you had Examples of all the Varieties both of *Eaſt*, *Weſt*, *North*, and *South Reclining* Plains; and no other can poſſibly fall out in any Place whatſoever. The Inclining Plains are the ſame with the *Recliners* oppoſite to them; and muſt be drawn in the ſame manner as hath been (in ſome Meaſure) heretofore hinted, and ſhall be more at large diſcourſed of hereafter, when I have done with *Declining Reclining* Plains, of which I come now to treat.

IV. *Of Declining Reclining Plains.*

CHAP. XIX.

AS there were ſix Varieties of Direct North and South Reclining Plains, ſo alſo are there of South and North Declining Reclining Plains, *viz*. Three Varieties of South *Recliners Declining*, and as many of North *Recliners Declining*. For in South *Recliners Declining*,

1. THE *Declining* may be ſuch, that the South *Reclining Plain* may cut or fall upon the Meridian, juſt upon the Pole-point; and ſuch *Reclining Declining Plains*, are called *Equinoctial Decliners*: Or,

2. THE *Declination* may be ſuch, that the *Reclining Plain* ſhall interſect the Meridian between the Zenith of the Place, and the Pole of the World: Or,

3. THE *Declination* may be ſuch, that the *Reclining Plain* ſhall croſs the Meridian between the Pole and the Horizon.

Theſe are the three Varieties of South Recliners Declining. *In* North Recliners Declining *there are three other Varieties. For,*

1. THE *Declination* may be ſuch, that the North Reclining Plain may croſs the Meridian in the Point where the *Equinoctial* interſects the Meridian. And then ſuch Plains are called Polar Declining Plains, becauſe the Poles of them lie in the *Axis of the World*, and the *Subſtile* in ſuch Plains will be always perpendicular to the Meridian of the Place.

2. THE *Declination* may be ſuch, that the Reclining Plain may interſect the Meridian, between the *Zenith* and the *Equinoctial*: Or,

3. THE *Declination* may be ſo much, that the Reclining Plain may fall upon the Meridian, between the *Equinoctial* and the *Horizon.*

Examples of all theſe Varieties follow.

I. *Of South Recliners.*

The Firſt Variety.

CHAP. XX.

How to draw the Hour-lines upon a South Reclining Declining Plain, which cutteth the Meridian in the Pole Point.

IN Declining Reclining Dials, before the Hour-lines can be drawn, Three Things muſt be given, and four Things found: The Things given re,

Given
- 1. The Latitude of the Place.
- 2. The Declination of the Plain.
- 3. The Plain's Reclination.

The Things required, are,

Required
- 1. The Diſtance of the Meridian and Horizon.
- 2. The Height of the Pole above the Plain.
- 3. The Diſtance of the Subſtile and Meridian.
- 4. The Plain's Difference of Longitude.

Let the Example be of a South Plain Declining Eaſt, 30 deg. and Reclining 34 deg. 32 min. in the Latitude of London, 51 *deg.* 32 *min.*

Firſt, Draw the Circle H A O R, and croſs it with the two Diameters H Q O, the Horizontal Line of the *Plain*, and A Q R, the perpendicular Line of the *Plain*, croſſing each other at right Angles in Q, the Center of the *Plain*.

Plate 5. *Fig*. 4.

Secondly, Becauſe the *Plain* reclined 34 deg. 32 min. Take 34 deg. 32 min. from your Line of Chords, and ſet them upon your *Plain* from A to *a*, from H to *b*, and from R to *c*.

Thirdly, Lay a Ruler from O to *a*, and it will cut the perpendicular Line of the *Plain* in Z the Zenith of the Place. Alſo a Ruler laid from O to *b*, will cut the *Plain*'s Perpendicular in K, the Interſection of the Horizon of the Place, with the *Plain*'s Perpendicular. And a Ruler laid from O to *c*, will cut the perpendicular of the *Plain* A R, (it being extended) in N the Nadir-point. Having found theſe Points upon the perpendicular Line of the *Plain*.

Fourthly, Through the Points H K O, draw the Horizon of the Place. And,

Fifthly, Becauſe the *Plain* declines 30 deg. Eaſtward, take 30 deg. out of your Chord, and ſet them from R to *d*, and from O to *e*; and laying a Ruler from Z the Zenith to *e*, it will croſs the Horizon in E, the Eaſt point thereof, and the Ruler laid from Z to *d*, will croſs the Horizon in S the South point thereof; ſo have you found three Points, *viz*. Z N and S, through which you may draw the Meridian, whoſe Center you may find, as hath been before taught: Or in this Manner,

Divide the Space between Z and N in two equal Parts in C, and through C draw the Line C D parallel to Q O, extending it as you ſhall have Occaſion. Alſo from Q, through E, draw another Right Line Q E, extending it, as Occaſion ſhall offer; the Point of thoſe two Lines Interſection is the Center of the Meridian. Which being drawn,

Sixthly, Lay a Ruler from E the Eaſt point of he Horizon to Z the Zenith, and it will cut the *Plain* in *h*. And becauſe the Pole of the World s diſtant from the Zenith 38 deg. 28 min. equal o the Complement of the Latitude, ſet 38 deg. 8 min. from *h* upon the *Plain*, and it will fall uſt upon *P*, which is the Point of the *Plain*'s In-erſection with the Meridian, which demonſtrates he Pole to have no Elevation above the *Plain*, nd ſo the *Plain* to be *Equinoctial Declining*.

Seventhly, Draw the Line P Q L for the Axis f the World, and becauſe the Equinoctial Circle in all Parts diſtant from either Pole 90 deg. ſet o deg. from P or L, to Æ; and through Q, raw the Line Æ Q æ, for the Equinoctial Circle, hich is here a ſtrait Line, and being extended, ould paſs through the Center of the Meridian, nd alſo through the Eaſt and Weſt Points of the orizon, as it ought to do.

The Scheme being thus projected, the four Re-uiſites from it are eaſily obtained. For,

1. *To find the Diſtance of the Meridian, and the Horizon* O P. The Arch O P meaſured upon

your Line of Chords, will contain 71 deg. 53 min. the Diſtance required.

2. *The Height of the Pole above the Plain* (the point P) 00 deg. 00 min. therefore it is an Equinoctial Declining *Plain.*
3. *The Diſtance of the Subſtile and the Meridian,* the Point P alſo. Therefore that, as alſo all the Hours muſt be parallel to the Subſtile.
4. *To find the Plain's Difference of Longitude,* Q P B. Lay a Ruler from P to B, and it will cut the *Plain* in *m*, the Diſtance L M meaſured upon your Chord, is the *Plain's* Difference of Longitude 24 deg. 19 min.

THESE Requiſites being thus found, I will now ſhew,

How the Hour-lines are to be drawn upon the Plain.

Firſt, Draw a Line as B A C for the Horizontal Line of your *Plain*, and upon any convenient Point therein, as upon A, with 60 deg. or the Radius of your Line of Chords, deſcribe the Semicircle B D C.

Secondly, From your Line of Chords take 71 deg. 53 min. the Diſtance of the Meridian and Horizon, and ſet them from B to D, and draw the Line A D for the Subſtile.

Thirdly, Take 24 deg. 19 min. the *Plain's* Difference of Longitude, and that Diſtance from D to E, and draw the Line A E.

A South Plain declining Eaſt 30 *d. reclining* 34 *d.* 32 *m. Pl.* 5 *Fig.* 5.

Fourthly, Divide the Semicircle B C D into 12 equal Parts at the Points ⊙ ⊙ ⊙, &c. beginning the Diviſion at the Point E.

Fifthly, Through the Point O, (or any other Point taken at all Adventures in the Subſtilar Line) draw a Line M O N at right Angles, (or perpendicular) to the Subſtilar, repreſenting the Equinoctial.

Sixthly, Lay a Ruler from A, and every of the Points ☉ ☉ ☉, *&c.* in the Semicircle, and it will croſs the Equinoctial in the Points * * *, *&c.*

Laſtly, If through theſe Points * * *, *&c.* you draw right Lines parallel to the Subſtilar, they ſhall be the true Hour-lines belonging to your *Plain*, the Hour-line of 12 being that where you began to divide your Semicircle, that is, at the Mark (or *) which was made from the Point E.

For the Stile of this Dial, it may be either a ſtrait Pin or Wire, of the juſt Length of the Line A O, erected perpendicularly upon ſome Point of the Subſtile (as at A or O) the very Top of the Shadow thereof, giving the Hour among the Hour-lines upon the Dial.

Or elſe the Stile may be a Plate of Braſs or Iron of the Breadth of A O, ſet perpendicular to the *Plain*, upon the Subſtilar Line A O D, the Shadow of whoſe upper Edge ſhall give the true Hour of the Day.

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* * *

The Second Variety.

CHAP. XXI.

How to draw the Hour-lines upon a South Reclining Plain, *Declining Eaſt or Weſt, which paſſeth between the Zenith and the Pole.*

IN this, as in all other Decliners Reclining, three Things muſt be known, and four muſt be found before the Drawing of the Hour-lines.

Let the Example be a South Reclining Plain, Declining *Eaſt* 30 *deg. and* Reclining 20 *deg. in the Latitude of* 51 *deg.* 32 *min.* London.

Given	1. Latitude of the Place	51	32
	2. Declination South Eaſt	30	00
	3. Reclining South.	20	00

Required
1. The Diſtance of the Meridian and Horizon.
2. The Height of the Pole above the Plain.
3. The Diſtance of the Subſtile and the Meridian.
4. The Plain's Difference of Longitude.

Firſt, Deſcribe the *Circle* H A O R, repreſenting your *Reclining Declining Plain*, and croſs it at right Angles, with the two Diameters A R, for

the

he Perpendicular, and H O, for the Horizontal Line of the Plain.

Secondly, Take 20 deg. the Plain's Reclination, out of your Chord, and ſet them from A to *a*, from O to *b*, and from R to *c*.

Plate 5. *Fig.* 6.

Thirdly, A Ruler laid from H to *a*, will give you Z the Zenith, and laid from H to *b*, will give you K the Interſection of the Horizon with the perpendicular Line of the Plain. And the Ruler laid from H to *c*, will give you N the Nadir, then through the points H, K and O, draw the Horizon H K O.

Fourthly. Take 30 deg. the plain's Declination out of your Line of Chords, and ſet them from R to *d* weſtward, (becauſe the Plain declines Eaſtward) and alſo from O to *e*, ſo a Ruler being laid from Z to *e*, ſhall cut the Horizon in E, the Eaſt point thereof, and laid from Z to *d*, ſhall cut the Horizon in S, the South point thereof. Thus have you three Points Z, S and N, through which to draw the Meridian Circle, which you may extend without the plain to P and N, occaſion ſometimes requiring it ſhould be ſo.

Fifthly, Foraſmuch as the Pole of the World is always diſtant from the Zenith equal to the Complement of the Latitude of the place, as here at *London*, 38 deg. 28 min. Lay a Ruler from E to Z, and it will cut the Plain in *h*, from whence ſet 38 deg. 28 min. to *k*. So a Ruler laid from E to *k*, will cut the Meridian (extended) in the point P, the North pole of the World. And a Ruler laid from P to Q, ſhall croſs the Meridian in L, the South-pole, and the Line P Q L, ſhall be the Axis of the World.

Sixthly, Take 90 deg. of your Chords, and ſet them from *k* (the point which found the pole at P) to *n*: So a Ruler laid from E to *n*, ſhall cut th Meridian in B, through which point, and throug the point E, the *Equinoctial Circle* muſt be deſcribed, whoſe Center will be in the Axis P L extended, and the Manner how to find it, hath been ſeveral Times already diſcovered.

THE *Horizon*, *Meridian* and *Equinoctial Circl* being thus deſcribed upon your Plain, by their Interſections and Diſtances, the four Requiſites belonging to this *Declining Reclining Plain* may be obtained. As,

1. *To find the Diſtance of the Meridian and Hozon* H V. The Diſtance H V upon the Plain, meaſured upon the Line of Chords will contain 78 deg. 50 min. the Diſtance of the Meridian and Horizon.
2. *To find the Height of the Pole or Stile, above the Plain L c.* Set 90 deg. from *c* to *b*, then lay a Ruler from *b* to L, and it will cut the plain at *m*, the Diſtance from *c* to *m*, meaſured upon your Chords, will contain 13 deg. 40 min. the Height of the *Pole* or *Stile* above the Plain.
3. *To find the Diſtance of the Subſtile from the Meridian V c*, meaſure the Diſtance *V c* upon the Line of Chords, and it will contain 7 deg. 30 min. the Diſtance required.
4. *To find the Plain's Difference of Longitude, B L D.* Lay a Ruler from L to B, it will cut the plain in *h*, ſo the Diſtance *h a* meaſured upon the Line of Chords, will contain 28 deg. 52 min. the plain's Difference of Longitude.

THUS are the four Requiſites belonging to this *Plain* found, and in this Example, two Things re very obſervable.

1. WHEREAS P the North-pole of the World, falls without the *Plain*, and the point L, repreſenting the South Pole, falls within the *Plain*, it denotes that the South pole muſt be elevated.
2. IN reſpect that the Line or Arch L *c*, which is the Height of the Stile or Pole above the Plain, is but of ſmall Quantity, *viz.* 13 deg. 40 min. it will from thence follow, that the *Equinoctial* Center will be very remote, and that the Hour-lines near to the Subſtile will be very cloſe, ſo that in ſmall *Dials* their Diſtances one from another will be inſenſible; and therefore you may ſave the Labour of deſcribing the *Equinoctial Circle*, and be ſatisfied in finding of the point B, by which the *Plain*'s Difference of Longitude is found. For, in ſuch Caſes as this, the *Plain*'s Difference of Longitude, the Diſtance of the Meridian from the Horizon, and of the Subſtile's Diſtance from the Meridian, and the Height of the *Pole* above the *Plain* being gained, you may proceed to draw the *Dial* as followeth, not much differing from the drawing of the Upright far declining *Dial*, Chapter VIII.

How to draw the Hour-lines upon the Plain.

Firſt, Draw a right Line A B C for the *Horizontal* Line of your *Plain*, and aſſume any convenient Place therein, as B for a Center; upon which point, with 60 deg. of any large Line c Chords, (*For it is neceſſary, not only in this, bu for divers other Occaſions, to have ſeveral Lines Scales of Chords upon your Ruler, or elſe uſe a Sector, whic ſupplies them all)* deſcribe th Arch of the Circle A D. Upon this Arch, from A to D ſet 78 deg. 50 min. the Diſtance of the Meridian from the Horizon, and not the point E, but you need not draw the Meridia Line.

South Declining East 30 deg. Reclining 20 deg. Plate 5. Fig. 7.

Secondly, From D to E ſet 7 deg. 30 min. th Diſtance of the Subſtile from the Meridian, th ſame way as you find it to lie in your Projection and draw the Line B E for the Subſtile. Alſo upon the ſame Arch, ſet off 13 deg. 40 min. th Height of the Stile from E to F, and draw th Line B F for the Stile. Which being but of ſmal Elevation, *viz.* 13 deg. 40 min. ought to be augmented; and therefore (at any convenient Diſtanc ſuitable to the Bigneſs of your Dial-plain) draw Line as G H, parallel to B F, for your augmented Stile or Axis.

Thirdly, Through any two Points taken at Adventure in the Subſtilar Line, as K and L, draw two right Lines perpendicular, or at right Angle to the Subſtilar, as the Lines M K N, and O L P. Then from the Point K, take the leaſt Diſtance to the augmented Stile G H, and ſet tha Diſtance upon the Subſtilar K to Q. Alſo from the Point L, take the neareſt Diſtance to the augmented Stile G H, and ſet that Diſtance upon the Subſtilar from L to R.

Fourthly Upon the Points Q and R, as upon two Centers, with 60 deg. of any of your Chords deſcribe two Semicircles (or other Portions of

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p. 83

Fig. 1

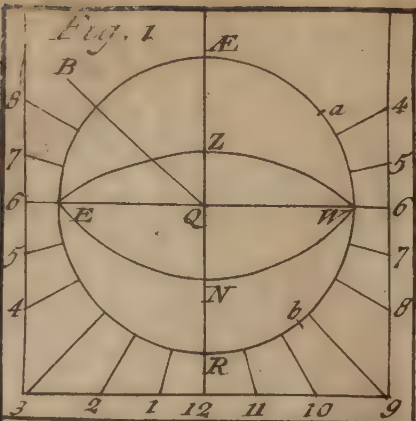


Fig. 2

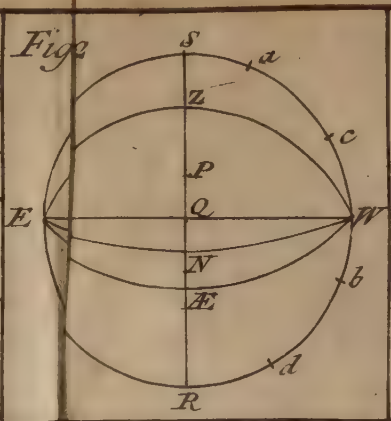


Fig. 3

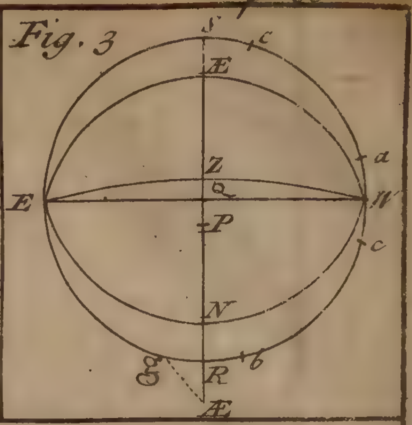


Fig. 4

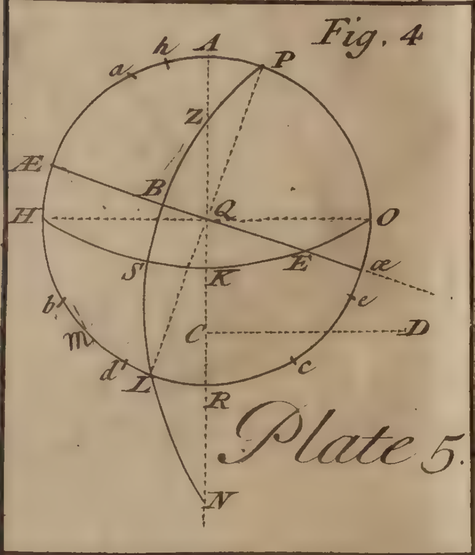


Plate 5.

Fig. 5

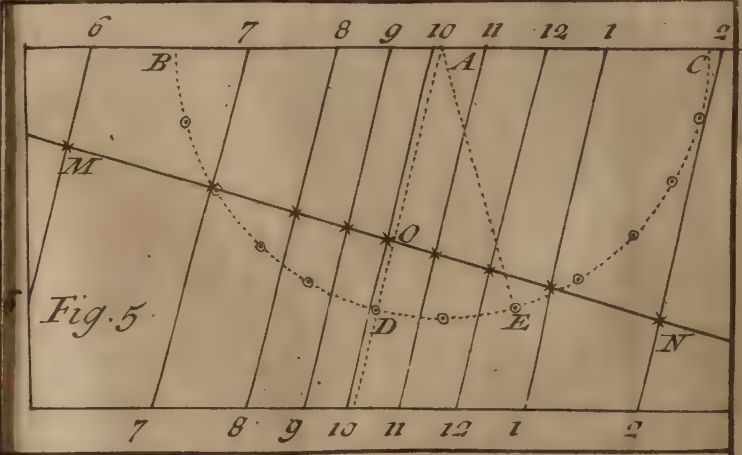


Fig. 6

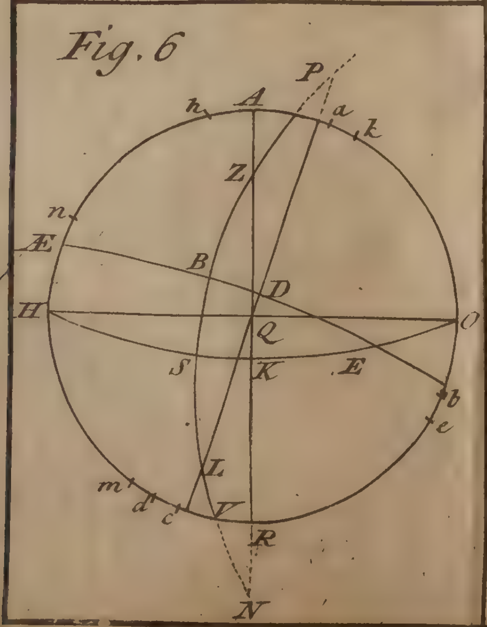
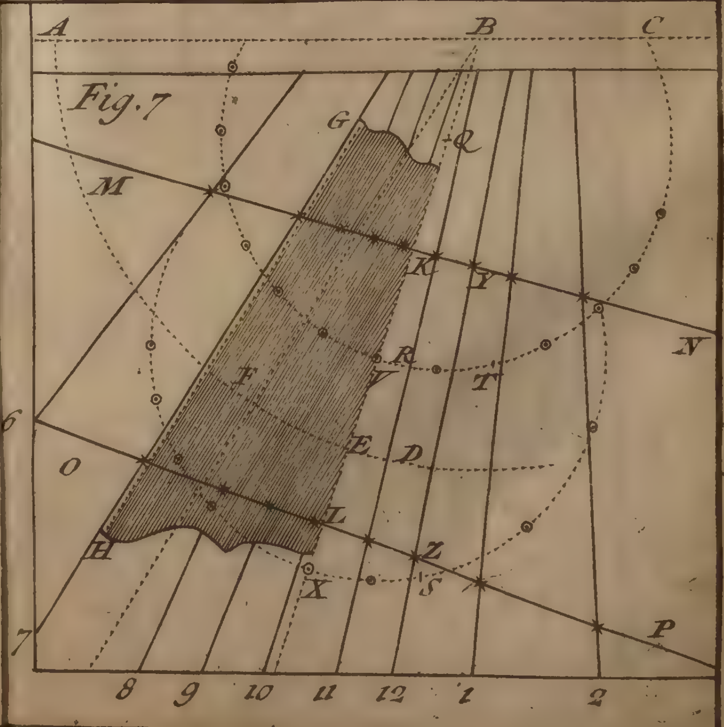


Fig. 7



Circles) and in either of them ſet 28 deg. 52 min. from V to T upon one of them, and from X to S upon the other.

Fifthly, Lay a Ruler from Q to T, and it will cut the Tangent Line in Y: Alſo lay a Ruler from R to S, and it will cut the other Tangent Line in Z, and a right Line drawn through the Points Y and Z, ſhall be the Hour-line of 12.

Sixthly, At the Points S and T, begin to divide the ſeveral Semicircles in 12 equal Parts or Hours, by taking 15 deg. of your Chord, and ſetting them from S and T both ways at the Points ⊙ ⊙ ⊙, &c. ſo many Times as the *Plain* will receive Hour-lines.

Seventhly, Lay a Ruler from the Points Q and R, to every of the Points ⊙ ⊙ ⊙, &c. in their reſpective Semicircles, and it will croſs their ſeveral Tangent Lines in the Points ***, &c.

Laſtly, Through the Points * * *, in both the Tangent Lines, draw right-lines, each to his Correſpondent, which the Hour-line of 12 will direct you how to do, and thoſe ſhall be the true Hour-lines of your *Plain*.

For the Stile of this *Dial*, it may be either of Wire or Plate, containing an Angle equal to the Height of the Pole above the *Plain*, but it muſt be augmented anſwerable to the augmented Stile, as you ſee in the Figure, and muſt be ſet in its proper Place upon the Subſtilar Line, and alſo perpendicular or ſquare to the *Plain*, and ſo is this *Dial* finiſhed.

The Third Variety.

CHAP. XXII.

How to draw the Hour-lines upon a South Reclining Plain, declining Eaſt or Weſt, which interſects the Meridian between the Pole and the Horizon.

LET the Example for this third and laſt Variety of South *Declining Reclining Plains* be of a South *Plain* declining Eaſtward 30 deg. and reclining 55 deg. in the Latitude of 51 deg. 32 min. *viz.* London.

		d.	*m.*
Given	1. The Latitude of the Place.	51	32
	2. The Declination Eaſtward	30	00
	3. The Reclination.	55	00

Required
1. The Diſtance of the Meridian from the Horizon.
2. The Height of the Pole or Stile above the Plain.
3. The Subſtile's Diſtance from the Meridian.
4. The Plain's Difference of Longitude.

Firſt, Draw the Circle A H R O, for your reclining declining *Plain*, and croſs it with the two Diameters A R the Vertical, and H O the Horizontal Line of the *Plain*.

Secondly, Set 55 deg. the *Plain*'s Reclination from A to *a*, and from O to *b*.

Thirdly, Lay a Ruler from H to *a*, (*Pl.* 2. *Fig.* 5.) and it will give you Z the Zenith, and laid from H to *b*, it will give you K, the Point of the Horizon's Interſection with the *Plain*'s Vertical Line. So have you three Points H K and O, through which to deſcribe the Horizon of the Place H K O.

Fourthly, Set 30 deg. the *Plain*'s Declination from R to *c* Weſtward, (becauſe the *Plain* declines Eaſtward) and from O to *d*. So a Ruler laid from Z to *c*, ſhall give you S, the Interſection of the Meridian with the South point of the *Horizon*. And the Ruler laid from Z to *d*, ſhall give you E the Eaſt point of the Horizon.

Fifthly, Having the Points S and Z, through them you may draw the Meridian Circle L S Z P, as hath been already ſeveral ways taught, the Center whereof will fall in the Line Q E being extended.

Sixthly, Lay a Ruler from E to Z, and it will cut the *Plain* in *e*, from which Point *e*, ſet 38 deg. 28 min. to *f*, and a Ruler being laid from E to *f*, ſhall give the point P, upon the Meridian Circle for the Pole of the World. And a right Line drawn from P through Q, ſhall be the Axis of the World, and the Subſtilar Line of the *Dial*.

Seventhly, Set 90 deg. from *f* to *h*, (becauſe the *Equinoctial Circle* is in all places 90 deg. diſtant from either *Pole* P or L.) So laying a Ruler from E to *h*, it will give you the point B in the Meridian, through which, and E, the Eaſt point of the Horizon, the *Equinoctial Circle* muſt paſs, may be drawn as in former Examples, the Center thereof being in the Axis of the World, P L extended.

THESE three principal Circles, *viz.* the *Horizon*, *Meridian* and *Equinoctial*, being deſcribed, according to their true Situations upon the *Plain*, the ſame forementioned Requiſites may from thence be eaſily deduced, as followeth.

1. *To find the Diſtance of the Meridian from the Horizon* O C. The Arch O C, meaſured upon the Line of Chords, will contain 64 deg. 41 min. *The Subſtile's Diſtance from the Meridian.*
2. *To find the Height of the Pole or Stile above the Plain* P D. Set 90 deg. from D to *æ*, and lay a Ruler from *æ* to P, it will cut the *Plain* in *m*, the Arch D *m* meaſured on the Line of Chords, will contain 19 deg. 25 m. *The Height of the Stile.*
3. *To find the Subſtile's Diſtance from the Meridian* C D. This Arch meaſured will contain 6 deg. 2 min. *The Diſtance of the Subſtile from the Meridian.*
4. *The Plain's Difference of Longitude* B P Q. A Ruler laid from P to B, will cut the *Plain* in *k*. So the Diſtance F *k* meaſured, will be 17 deg 38 min. *The Plain's Difference of Longitude.*

THESE Requiſites being thus found, you may proceed to draw the Hour-lines in this as in other *Plains*. Firſt, By laying a Ruler upon P the Pole of the World, to B, in the Interſection of the Meridian and Equinoctial, which will cut the Plain in *k*, at which point, begin to divide the Semicircle into 12 equal Parts. And from Q, to each of them, lay a Ruler croſſing the *Equinoctial Circle*, and dividing that into 12 unequal parts, to which unequal Parts of the Equinoctial, a Ruler laid, it will divide the *Plain* into 12 other unequal parts, through which, and the Center Q, right Lines being drawn, they ſhall be the true Hour-lines proper for the Plain.

But in this Example, the Elevation of the Pole or Stile above the Plain, being but ſmall, *viz.* 19 deg. 25 min. you may, if you pleaſe, draw the Hour-lines by one Tangent-line, and the Center, as was ſhewed in the ſecond Variety of Direct South Reclining Plains; and as here followeth.

How to draw the Hour-lines upon the Plain.

Firſt, Upon your Plain, towards the Bottom thereof (becauſe the North Pole is here elevated) draw a right Line A B, parallel to the Horizon, and aſſume A for the Center of your Dial, upon which point, with 60 deg. of your Chords, deſcribe an Arch of a Circle B E, upon which from B, ſet the Diſtance of the Meridian and Horizon, 64 deg. 41 min. to C, and draw the Line A C for the Hour-line of 12. Alſo, upon the ſame Arch from C to D, ſet 6 deg. 2 min. the Diſtance of the Subſtile from the Meridian; and draw the Line A D for the Subſtilar.

Again, upon the ſame Arch ſet off 19 deg. 25 min. the Height of the Stile from D to E, and draw the Line A E for the Axis of the Stile.

A South Plain *declining Eaſtward* 30 *deg. and reclining* 55 *deg. Pl.* 6 *Fig.* 1.

Secondly, Upon any part of the Subſtilar Line, aſſume any point at pleaſure, as F, through which draw the right Line G F H perpendicular to the Subſtile.

Thirdly, From the Point F, take the neareſt Diſtance to the Axis of the Stile, and ſet that

Diſtance upon the Subſtilar Line from F to O, and upon the point O with 60 deg. of your Chord deſcribe the Semicircle M L N.

Fourthly, Lay a Ruler from O to K, (the point where the Tangent (or Equinoctial Line) croſſeth the Meridian) and the Ruler will cut the Semicircle in L, at which point begin to divide it into 12 equal parts in the points ⊙ ⊙ ⊙, *&c.*

Fifthly, Lay a Ruler from O the Center of the Semicircle to the ſeveral points ⊙ ⊙ ⊙, in the Semicircle, and the Ruler will cut the Tangent Line in the points * * *, *&c.*

Laſtly, If from the Center A, through theſe points * * *, *&c.* you draw right Lines, they ſhall be the proper Hour-lines belonging to your Plain.

For the Stile it may be either Plate or Wire, elevated above the Subſtile to an Angle of 19 deg. 25 min. and ſet up perpendicularly upon the Subſtilar, as in all other Dials. And thus have I done with all the Varieties of South Declining Reclining Plains.

II. *Of North Recliners.*

The Firſt Variety.

CHAP. XXIII.

How to draw the Hour-lines upon a North Reclining Plain, Declining Eaſt *or* Weſt, *which cutteth the Meridian at the Interſection thereof with the* Equinoctial.

LET the Example be of a North Plain Declining to the Weſt 60 deg. and Reclining from the Zenith 32 deg. 11 min. in the Latitude of *London*, 51 deg. 32 min.

		d.	m.
Given	1. Latitude of the place	51	32
	2. Declination of the Plain North Weſt.	60	00
	3. Reclining North.	32	11

Required
1. The Diſtance of the Meridian and Horizon.
2. The Height of the Pole or Stile above the Plain.
3. The Diſtance of the Subſtile and the Meridian.
4. The Plain's Difference of Longitude.

		deg.	min.
North	Declining *Weſt*	60	00
	Reclining	32	11

Firſt, Deſcribe the Circle A H C O for the Declining Reclining Plain; croſs it at right Angles with the two Diameters H O for the Horizontal, and A C for the Vertical Line of the *Plain.*

Plate 6. *Fig.* 2.

And here for Variety, more than for Neceſſity, in theſe three following Examples of *North Recliners Declining*, I will (in the ſeveral Schemes) place the Zenith and Pole downwards, becauſe the Stile in all theſe Dials muſt point upwards, the North pole being always elevated; and in ſo doing, the Hour-lines, Stile, and Subſtile, will ſtand in the Scheme as they are to ſtand in the Dial; and the manner of the Work will be the ſame as before. Wherefore,

Secondly, Set 32 deg. 11 min. the *Plain*'s Reclination, from O to *a*, and from C to B. A Ruler laid from H to *a*, ſhall give you the point Æ, through which, and the points H and O, the Horizon, H Æ O is to be deſcribed. And a Ruler laid from H to *b*, ſhall give you Z the Zenith point.

Thirdly, Set 60 deg. the Plain's Declination from A to *d*, a Ruler laid from Z the Zenith to *d*, ſhall cut the Horizon in S, the South point thereof. Thus have you two points Z and S, through which to draw the Meridian, whoſe Center will be in the Line Q E extended, and may be found as formerly is taught.

Fourthly, The Horizon and Meridian being thus drawn, lay a Ruler from E to Z, and it will cut the *Plain* in *e*; and ſeeing the Pole is 38 deg. 28 min. diſtant from the Zenith, ſet 38 deg. 28 min. from *e* to F, and a Ruler laid from E to F, will cut the Meridian in P the Pole of the World, through which point P, and the Center Q, draw the Line P Q for the Axis of the World, and *Subſtile* of the *Dial*. And again, becauſe the Equinoctial is 90 deg. from the Pole, ſet 90 deg. from F, and they will reach juſt to Æ or *æ* on either ſide, which are the very Points that the *Plain* cuts the Meridian in, and through which Points and the Point E, in the Horizon, the *Equinoctial Circle* muſt paſs; whoſe Center will always be in the Axis of the World P Q extended.

THE *Horizon*, *Meridian*, and *Equinoctial*, being thus drawn, you may find the four Requiſites in this manner.

1. *To find the Diſtance of the Meridian from the Horizon* Æ O. The Arch Æ O meaſured by your Line of Chords, will be found to contain 47 deg. 18 min. which is the *Subſtile*'s Diſtance from the Meridian.
2. *To find the Height of the Pole or Stile above the Plain* P F. A Ruler laid from *æ* to P, will cut the *Plain* in O; ſo the Diſtance F O on the Chords 42 deg. 52 min. is the Height of the Pole above the *Plain*.
3. *The Diſtance of the Subſtile from the Meridian* *æ* G, which meaſured upon your Chord, will be found to contain juſt 90 deg.
4. *The Plain's Difference of Longitude* G P *æ*, *or the Arch* *æ* G, as before alſo 90 deg. juſt.

In this Scheme two Things are remarkable.

1. The *Plain's* cutting the Meridian in its Interſection, with the Equinoctial. And,
2. The Axis of the World paſſing through the Eaſt Point of the *Horizon*, both which denote the *Plain* to be polar Declining, and the *Subſtile* to be the ſame with the Hour-line of 6. and the Hour-line of 12 at right Angles thereto, wherefore the Hour-lines may be drawn, as followeth.

To draw the Hour-lines upon the Plain.

Firſt, Lay a Ruler from P to Æ, where the Meridian and Equinoctial interſect, which is upon the *Plain* at the very Point Æ, wherefore there begin to divide the Semicircle Æ G *æ*, into 12 equal Parts at the Points ⊙ ⊙ ⊙, *&c.*

Secondly, Lay a Ruler to Q, and every of the Points ⊙ ⊙ ⊙, *&c.* and it will cut the Equinoctial in the Points * * *, *&c.* dividing that into 12 unequal parts.

Thirdly, A Ruler laid to P, and the ſeveral Points * * *, *&c.* in the Equinoctial, will cut the *Plain* in the Marks I I I, *&c.*

Laſtly, A Ruler laid from Q to the ſeveral Marks, I I I, *&c.* and ſtrait Lines drawn thereby, ſhall be the true Hour-lines fitting this polar Declining Plain.

For the Stile, it muſt be a Plate or Wire ſet upright upon the *Subſtilar* to an Angle of 42 deg. 52 min. and muſt point upwards to the North-pole.

The Second Variety.

CHAP. XXIV.

How to draw the Hour-lines upon a North Reclining Plain, *Declining Eaſt or Weſt, the Plain paſſing through the Meridian, between the Zenith and the Equinoctial.*

IN this, (as in the former Examples) three Things muſt be given, and four found, before the Hour-lines can be drawn.

		deg.	m.
Given	1. Latitude of the Place	51	32
	2. The Declination of the Plain North W.	60	00
	3. The Plain's Reclination.	16	00

Required
1. The Diſtance of the Meridian from the Horizon.
2. The Height of the Pole or Stile above the Plain.
3. The Subſtile's Diſtance from the Meridian.
4. The Plain's Difference of Longitude.

Firſt, Deſcribe the *Circle* A H C O for the *Plain*, and croſs it with the Diameters A C, and H O, for the Horizontal and Vertical Lines thereof.

Second-

A North Dial Declining Weſt 60
Reclining —— 16
Plate 6. *Fig.* 3.

Secondly, (As in the laſt Example) ſet 16 deg. the *Plain*'s Reclination, from O to *a*, and from C to *b*, a Ruler laid from H to *a*, ſhall give the Point B, through which, and the Points H and O, the Horizontal Circle H B O is to be deſcribed. Alſo a Ruler laid from H to *b*, ſhall find the Zenith Point of Z.

Thirdly, Set the *Plain's* Declination 60 deg. from A to *d*, and from H to *e* : So a Ruler laid from Z to *d*, ſhall cut the Horizon in S the South, and laid from Z to *e*, ſhall cut it in E the Eaſt point thereof; and now having two Points Z and S, through them you may draw the Meridian Circle, as hath been already taught.

Fourthly, Lay a Ruler from E to Z, it will cut the *Plain* in F, and 38 deg, 28 min. the Complement of the Latitude of the Place, ſet from F to *f*, and a Ruler laid from E to *f*, will cut the Meridian in P the Pole of the World, and 90 deg. more, being ſet forward from *f* to *m*, and a Ruler laid from E to *m*, will cut the Meridian in Æ, the Equinoctial's Interſection with the Meridian; ſo have you two Points Æ and E, through which the *Equinoctial Circle* muſt paſs, and a right Line drawn through P the Pole of the World, and Q the pole of the Plain, will be the Axis of the World, and the Subſtilar Line of the *Dial*.

THESE three Circles, *viz.* the *Horizon*, *Meridian*, and *Equinoctial*, being deſcribed, the forementioned four Requiſites may from thence be eaſily obtained. For,

1. *The Diſtance of the Meridian from the Horizon*, is the Arch F H, 64 deg. 29 min.

2. *The Height of the Pole or Stile above the Plain* P R. A Ruler laid from *æ* to P, will cut the *Plain* in *n*: So the Diſtance R *n* meaſured, will be found to be 30 deg. 59 min.
3. *The Subſtile's Diſtance from the Meridian*, is the Arch I M, 64 deg. 26 min.
4. *The Plain's Difference of Longitude* is the Angle Æ P Q, which to find, lay a Ruler from P to Æ; and it will cut the *Plain* in D, the Diſtance D I meaſured upon the Line of Chords, will give 76 deg. 10 min. for the *Plain*'s Difference of *Longitude*.

To draw the Hour-lines upon the Plain.

Firſt, Lay a Ruler upon P the Pole of the World, and Æ, the Interſection of the Meridian with the Horizon, and it will cut the *Plain* in D, at which Point begin to divide the Semicircle *æ* I D into 12 equal parts, at the Points ⊙ ⊙ ⊙, *&c.*

Secondly, Lay a Ruler from Q to the ſeveral Points ⊙ ⊙ ⊙, *&c.* and it will divide the *Equinoctial Circle* into 12 unequal parts in the Points * * *, *&c.*

Thirdly, A Ruler laid from P to every of theſe unequal Parts * * *, *&c.* will cut the *Plain* in theſe Marks I I I, *&c.* dividing that into 12 other unequal parts.

Laſtly, If you draw right Lines from Q, through every of theſe Marks I I I, *&c.* they ſhall be the true Hour-lines belonging to your *Plain*.

THE Stile may be either of Wire or Plate as in other *Dials*, and muſt be elevated above the *Subſtile*, to an Angle of 30 deg. 59 min. and muſt ſtand ſquare, or at right Angles to the *Plain*.

The Third Variety.

CHAP. XXV.

How to draw the Hour-lines upon a North Reclining, *or* Inclining Plain, Declining *Eaſt or Weſt, which interſects the Meridian between the Equinoctial and the Horizon.*

LET this third and laſt Example of North Recliners Declining, be of a North *Plain*, reclining 54 deg. and declining Weſtward 60 deg. in the Latitude of *London*, 51 deg. 32 min.

THIS being the third and laſt Variety of declining reclining Plains, I ſhall be ſomewhat the larger in the Projection thereof, than I have been in any of the foregoing; not but that this Dial is to be made in all reſpects like (and with the ſame Eaſe) as the former. But herein I ſhall ſhew at large the Manner of Projection, and how all the Centers are *Geometrically* found, and the Reaſons of their being in ſuch and ſuch Lines, and at ſuch and ſuch Diſtances. And alſo, I ſhall project all the *Hour-lines* belonging to the *Plain* upon the *Plain* it ſelf by circular Lines, by which Means the Reader may attain to a more competent Knowledge in what hath been heretofore in this Treatiſe delivered. For from this Projection following, all the aforeſaid hath been deduced. And therefore I ſhall deſcribe the Manner of the delineating of this Dial, according to the following Propoſition.

PROPOSITION.

PLATE VII.

A Circle being deſcribed, repreſenting a Declining Reclining *Dial-plain; how thereon to place the* Meridian, Horizon, Equinoctial, Pole, Zenith, *&c. with all other Requiſites belonging to ſuch a Dial. And alſo, to project the* Meridians *of the* Sphere *itſelf upon the* Plain, *and from thence to draw the Hour-lines upon the Dial-plain, according to their true Situation.*

LET the Circle H S O B, repreſent a Dial-plain in the Latitude of *London* 51 deg. 32 min. Declining from the North towards the Weſt 60 deg. 00 min. and reclining from the Zenith Northward 54 deg. 30 min.

Firſt, Croſs the Circle with the two Diameters H O, and S B, cutting each other at right Angles in the Center Q. And becauſe the *Plain* reclineth 54 deg. 30 min. take 54 deg. 30 min. out of your Line of Chords, and ſet that Diſtance upon your *Plain* from S to *a*, from O to *b*, and from B to *c*: Then lay a Ruler from H to *a*, and it will cut the Line S B in Z, ſo ſhall the point Z be the Zenith of the Place.

Secondly, Lay a Ruler from H to *b*, it will cut the Line S B in *k*, ſo ſhall *k* be a Point in the Line S B, through which the Horizon ſhall paſs: And thus having three Points H *k* O, you may through them deſcribe the Horizon, whoſe Center will be at *m*, the Diſtance *m k* being equal to the Secant of the Complement of the Reclination of the *Plain*; namely 36 deg. —— Or *Geometrically* thus, Draw the right Line *k* O, which divide into two equal parts in *n*, and upon the point *n*, raiſe a Perpendicular *n m*, extending it till it cut the Line S B in *m*, ſo ſhall *m* be the Center of the *Horizontal Circle* H *k* O.

Thirdly, Lay a Ruler from H to *c*, it will cut the Line S B (being extended) in the point N, ſo ſhall N be the Nadir-point.

Fourthly, Becauſe the *Plain* declines 60 deg. from the North Weſtward; ſet 60 deg. from B to *d*, and laying a Ruler to Z the Zenith, (which is alſo the Pole of the Horizon) to *d*, it will cut the Horizon in S, through which Point the Meridian muſt paſs.

Fifthly, Take (always) 90 deg. of your Line of Chords, and ſet that Diſtance from *d* to *e*, and laying a Ruler from Z to *e*, it will cut the Horizon in *w* the Weſt point thereof, and a Line drawn from *w*, through Q the Center of your *Plain*, will cut the Horizon (if you extend it as here is done) in E, the Eaſt-point thereof, and in ſome part of this Line (extended if need require) will the Center of the Meridian be; and where that Point will fall may be thus found.

Sixthly, Divide the Line Z N into two equal parts in F, and upon F erect the Perpendicular F D, cutting the Line Q *w* (extended) in D, ſo ſhall D be the Center of the Meridian of the Place.

Seventhly, If with your Compaſſes you take the Diſtance D P, and with that Extent upon D, as a Center, deſcribe a Circle, you ſhall find that Circle exactly to paſs through the reſpective points Z and N, if there be no former Error committed in your Work.

Eighthly, Becauſe the Height of the Pole above the Horizon, is equal to the Latitude of the place *viz.* at *London* 51 deg. 32 min. ſet off 51 deg. 32 min. upon the Meridian from S to P, in this Manner.

Ninthly, Lay a Ruler from *w*, the Weſt-point of the Horizon, (which is alſo the *Pole* of the Meridian) to S, and it will cut the *Plain* in *h*; then ſet 51 deg. 32 min. from *h* to *f*. A Ruler laid from *w* to *f*, will cut the Meridian in P, ſo is P the pole of the World, diſtant from Z the Zenith, 38 deg. 28 min. and a Line drawn thro' P the pole of the World, and Q the Center of the *Plain*, will be the Axis of the World, and (extended) will cut the Meridian in M the South pole.

Tenthly, The Meridian and Horizon being thus drawn, it is eaſy to deſcribe the Equinoctial; for if you conſider the poſition of that Circle in the Sphere it ſelf, you know that it always paſſes through the Eaſt and Weſt-points of the Horizon, and cutteth the Meridian at right Angles, it being in all Places 90 deg. diſtant from either of the Poles. Wherefore, if upon *w*, (the *Pole* of the Meridian) you lay a Ruler to P the Pole of the World, it will cut the *Plain* in *f*; and if you ſet 90 deg. from *f* to *g*, and lay a Ruler from *w* to *g*, it will cut the Meridian in Æ; ſo have you three Points, through which the Æquinoctial muſt paſs, namely, E Æ and *w*, and the Center of the *Equinoctial* will be the Axis of the World, extended if Need require. To find which, you muſt,

Eleventhly, Divide the Line E *w*, into two equal parts in G, and from the point G, upon the Line E *w*, erect the Perpendicular G K, cutting the Axis of the World in K, ſo ſhall K be the

Center of the Equinoctial; wherefore, if upon K as a Center, with the Diſtance K *w*, you deſcribe a Circle, that ſhall be the Equinoctial, and (if your Work be true) ſhall paſs through the points E Æ and *w*; then for the dividing of the Equinoctial.

Twelfthly, Lay a Ruler to P the pole of the World (which is alſo the pole of the Equinoctial to Æ, the Interſection of the Meridian and Equiquinoctial, and it will cut the *Plain* in the point 12, at which point you muſt begin to divide the Circle repreſenting your *Reclining Declining Plain* into 24 equal parts at the Points ⊙ ⊙ ⊙, *&c.* This done, lay the Ruler to the point P, and every of the 24 equal Parts ⊙ ⊙ ⊙, and you ſhall find it to cut the Equinoctial Circle in the points * * *, *&c.* dividing that Circle into 24 unequal parts, through which unequal parts, and the two Poles of the World P and M, muſt all the Hour Circles paſs. For the deſcribing whereof you muſt,

Thirteenthly, Divide the Line P M into two equal parts in the Point L, (or, from the Point D, the Center of the Meridian, let fall a Perpendicular upon the Axis of the World, which will fall in the ſame Point L) and through the Point L, draw an infinite right Line at right Angles to P M, namely, the Line C T, for in that Line will the Centers of all the *Hour-lines* be found, and the Manner how to find them is thus (one way) to be effected.

Fourteenthly, Upon the point P as a Center, at the Diſtance *P* L, (or to any other Radius of a Line of Chords) deſcribe the Semicircle X L V, and divide it into 12 equal parts at the Points · · · · *&c.* beginning your Diviſion at the Point J, which is, where the Ruler being laid from *P*, to

D

D (the Center of the Meridian) cuts this laſt drawn Circle. Then laying a Ruler from *P*, upon each of theſe Diviſions, you ſhall find it to cut the Line C T in the points 15, 30, 45, 60, *&c.* on either ſide of the Point D; and here note, that 15 is the Center of the firſt Hour's Diſtance from the Meridian on either Side thereof, 30 the Center of the ſecond, and 45 of the third Hour's Diſtance from the Meridian, *&c.*

Fifteenthly, If you place one Foot of your Compaſſes upon 15, and extend the other to *P* the Pole of the World, and with that Diſtance deſcribe a Circle, that Circle ſhall be the firſt Hour from the Meridian, and (if your Work be true) hall paſs through M the South *Pole*, and alſo hrough φ φ, the two firſt unequal Diviſions of he *Equinoctial Circle*, and ſo all the reſt.

Laſtly, If from Q the Center of your *Plain*, nd the reſpective Points where the Hour-circles ut the *Plain*, you draw ſtrait Lines, thoſe ſhall e the true Hour-lines proper for ſuch a *Declination* nd *Reclination*, as you formed your Projection or.

Now the Requiſites belonging to this, and the like Declining Reclining Plains, are,

			d.	m.
1. The Height of the Pole above the Plain.	Repreſented by	P A	54	43
2. The Diſtance of the Meridian and Horizon.		H Y	53	31
3. The Diſtance of the Subſtile from the Meridian.		Γ A	56	41
4. The Angle between the two Meridians.		Æ P R	61	47

All which may be meaſured upon the Projection, and ſo their Quantities found. As,

1. To find P A, lay a Ruler from P to *w*, where the *Equinoctial* and the *Plain* do interſect, and the Ruler will cut the *Plain* on the other ſide at *x*; ſo A *x* meaſured upon the Line of Chords, will be 54 deg. 43 min. the Height of the *Pole* above the *Plain*, (or P Q meaſured upon a Line of half Tangents, will contain 35 deg. 17 min.) the Complement thereof.
2. To find H Y, the Arch H Y, meaſured upon the Line of Chords, will give 53 deg. 31 min. the Diſtance of the Meridian from the Horizon.
3. To find Γ A, the Arch Γ A meaſured upon the Line of Chords, will give 56 deg. 41 min. the Diſtance of the Subſtile from the Meridian.

4. To find Æ P Q, Lay a Ruler to P the *Pole* of the World, and Æ the Interſection of the Meridian and the Equinoctial, and it will cut the *Plain* in *o*, the Arch *o* B meaſured upon the Line of Chords, will be found to contain 61 deg. 47 min. which is the Angle between the two Meridians.

Thus have you in this Scheme, delivered the true and genuine way of delineating Sun-Dials, deduced from the Sphere it ſelf, by which the Reaſon of all that hath been before delivered, is rendred obvious, and ſufficiently demonſtrative for this place. But here you ſee, that the Centers of the Meridians or Hour-circles fall out to be very remote, and that there will be required a large Tangent-line for their Deſcription, which will (for the moſt part) run out very far, and ſometimes, almoſt to an infinite Excurſion. I therefore choſe rather to ſhew, how the Hour-lines might be drawn, without having any Regard to this Tangent-line, or without projecting of the Hour-lines upon the *Circular Plain*, and therefore the Ways before delivered are far more apt for practice than this, though this be more ſatisfactory to the inquiſitive Reader, who will not be ſatisfied only with the doing, but of the underſtanding as well of what he does, and it is for the Satisfaction of ſuch, that I have here added this Propoſition.

CHAP. XXVII.

Concerning Inclining Plains, both Direct and Declining.

OF *Reclining Plains* there are but two Sorts, as hath been before inſtanced, and thoſe are either *Direct* or *Declining*. The *Direct* are thoſe *Reclining Plains* which do directly behold the *Eaſt*, *Weſt*, *North* and *South* Points of the Horizon: And the *Decliners* are thoſe which (beſides their Reclination from the Zenith) do reſpect two of the forementioned Cardinal Points, as,

(1.) The *South* and the *Weſt*.
(2.) The *North* and the *Weſt*.
(3.) The *South* and the *Eaſt*.
Or, (4.) The *North* and the *Weſt*.

The	First		South	declining	Reclining
	Second	ſort are	North	Weſt.	
	Third	called	South	declining	
	Fourth		North	Weſt.	

I alſo before intimated, and gave Examples, that of Direct Recliners, there were three Sorts, *viz.*

1. Such as Reclining from the Zenith, do behold either the due *Eaſt*, or due *Weſt* Points o the Horizon; and of this Sort there is only on kind, and no Variety in any Caſe. ——

2. *South Recliners*, of which there are three Varieties. ——

And 3. *North Recliners*, of which alſo there are three Varieties. ——

Again, Of *Reclining Declining*, I told you there were ſix Varieties alſo, as there were of Direct Recliners, *viz.* Three of South Declining *Plains* reclining, and as many of North reclining Declining *Plains*; of all which I have given Examples, and it may be now expected that I ſhould do the like for the Inclining Plains oppoſite to them, of which there are alſo as many Varieties, but ſeeing that the making of the reclining *Dial*, whether *Direct* or *Declining*, doth alſo make the Inclining *Dial*, whether *Direct* or *Declining* oppoſite thereunto, I ſhall ſave the Labour, and commend to the Ingenious Reader ſome few Rules by which he ſhall eaſily frame the Inclining *Dial* out of the Recliner. And,

I. *Of North and South Incliners.*

I will take for Example a South *Plain*, reclining 55 deg. which is the third Variety of South Recliners, and I would from that deduce the Hour lines proper for a North *Plain* inclining as much, *viz.* 55 deg. And it is eaſily effected. For,

If you draw the Hour-lines of the South Recliners 6 A B 6, and the Stile thereof alſo, quite through the Center Q, to the oppoſite part of the *Plain*, 6 C D 6, and ſet the ſame Numbers to the Hours on the right Hand in the Recliner, and the contrary, as the Figure clearly demonſtrates: And let the Axis in the North Incliner point downwards to the South Pole, as the Axis in the South Recliner doth upwards to the North Pole, and your Dial is finiſhed. Or you may effect this Work by pricking off the Hour-lines through the Paper, and turning it upſide down, and that will effect the ſame thing, only changing the Names of the Hours.

Plate 6. *Fig.* 4.

Or,

Or, again, if you turn the South reclining *Plain*, 6 A B 6 about, upon the Center Q, till the Line A B come to be in the place of C D, then will the Hours, Stile and all, be truly named and poſited; and the very South Recliner will become the North Incliner without any Alteration.

II. *Of Eaſt and Weſt Incliners.*

THERE is little Difference in drawing of the *Eaſt* or *Weſt* Inclining *Dials* from the reclining *Dials* oppoſite to them, from drawing the North Incliner before from the South Recliner. For,

IN the Example of the *Eaſt* and *Weſt* reclining and Inclining *Dial* before going, Chapter 10. The *Dial* as it there ſtands, repreſents an *Eaſt* or *Weſt* reclining *Plain*. But if you turn the *Dial* about upon the Center Q, till the Letter N come to be in the place of the Letter S, in that Figure, then will the ſame Dial repreſent both an *Eaſt* and *Weſt* *Dial* Inclining 35 deg. as now it doth an *Eaſt* or *Weſt* reclining as much. The Subſtile, Stile, Meridian, and the reſt of the Hour-lines retaining the ſame Names or Denominations, as now they do.

III. *Of North or South Declining Inclining Plains.*

OF North and South reclining Declining *Plains* there were ſix Varieties, Examples of each have been largely given. There are as many of North and South Incliners, but ſeeing they may be ſo eaſily deduced out of their oppoſite Recliners, I ſhall forbear giving Examples, and the Way is not much differing from the Rules before given for Direct reclining and inclining *Plains*. For ſeeing the Reclination is alike proper to each, and the Deflection of the Subſtile from the Meridian in the

Plate 6. p. 112

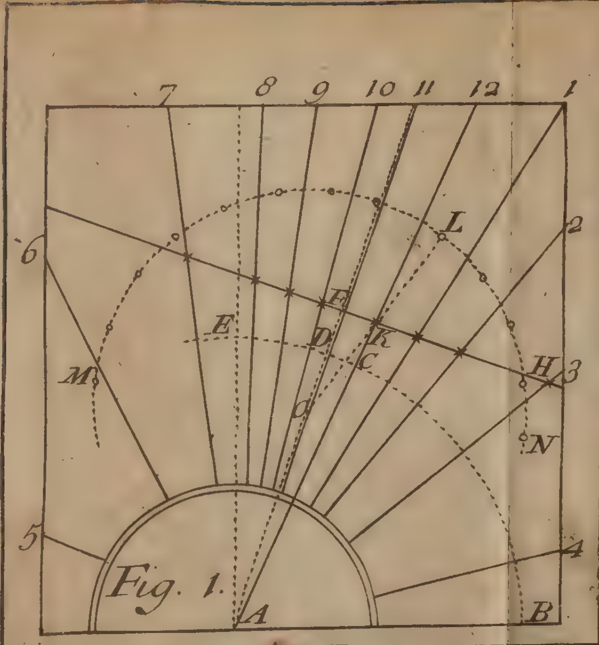


Fig. 1.

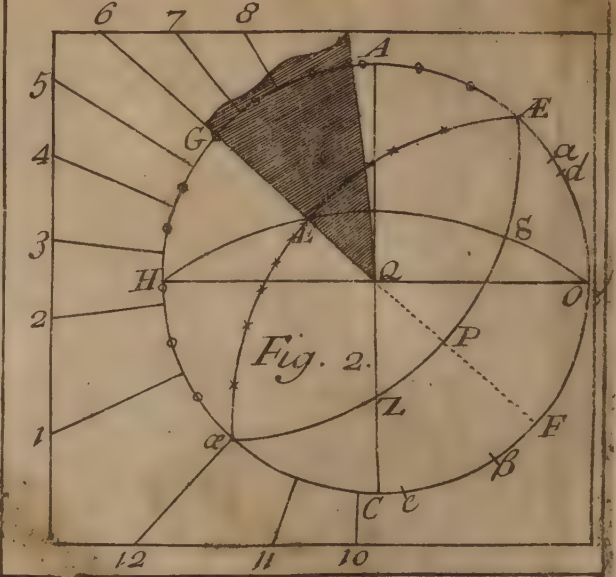


Fig. 2.

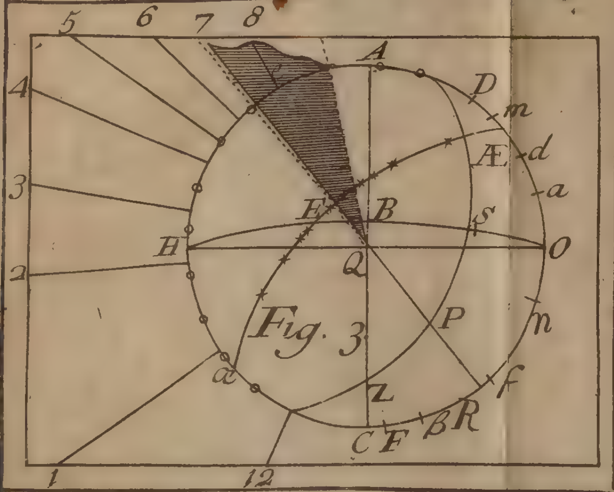


Fig. 3

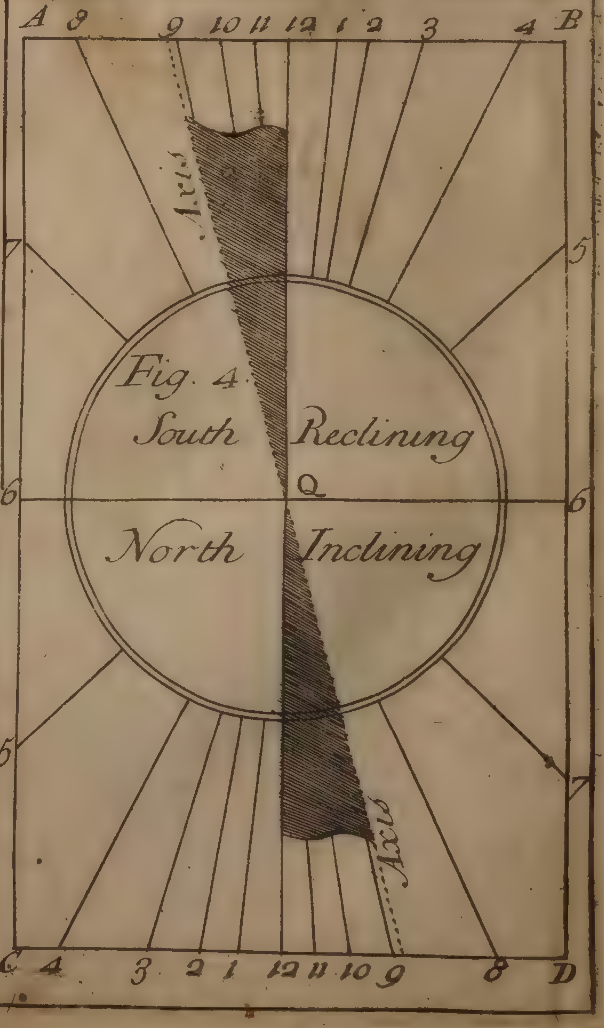


Fig. 4.

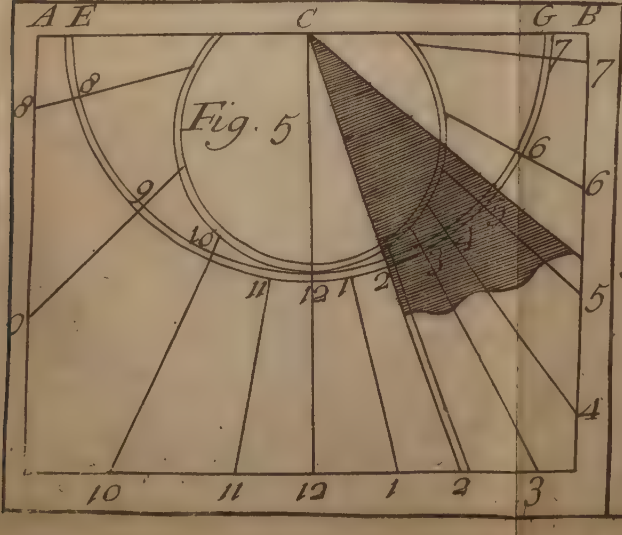


Fig. 5

the Declinations do ſo directly agree, they may both be reduced to one and the ſame *Dial*, as the other were.

Thus, If any reclining *Dial* be ſo inverted, that the upper Part thereof become the nether, and after this Inverſion the right Side of the Recliner become the left Side of the Incliner; and the contrary, the Inclining *Dial* having the ſame Declination, ſhall be framed out of the Recliner, and the contrary. Only the Denominations of the Hours muſt be changed. For the Fore-noon Hours in the Recliner, will be the After-noon Hours in the Incliner; and the Afternoon Hours of the upper Dial, the Forenoon Hours of the nether.

* * *

CHAP. XXVIII.

A General Rule to know which Pole, *whether the* North *or the* South, *is to be elevated over any* Plain.

THE Stile of every Dial reſpecteth (or rather lieth parallel with) the Axis of the World, and always pointeth upwards or downwards, to one of the Poles. Now when you have drawn your Dial (though truly) you may be to ſeek, whether it be the North or the South Pole that muſt be elevated; wherefore to avoid any Miſtake, and to inform you which Pole is to be elevated, Obſerve this General Rule.

Upon all upright Plains, whether direct or declining, upon the	South	ſide the	South	Pole.
	North		North	

Upon all Eaſt and Weſt	Recliners	the	North	Pole.
	Incliners		South	

Upon all	North Recliners	whether Direct or Declining	North	Pole.
	South Incliners		South	

Upon all	South Recliners	whether direct or declining.	If the Plain paſs between the	Zenith	and the Pole, the	South	Pole.
	North Incliners			Nadir		North	
				Horizon		South	

THIS Rule being duly obſerved, there will be no Difficulty to find which is elevated.

A Se-

A
Second Way
OF
DIALLING,
Geometrically Performed.

PART II.

IN the foregoing Firſt Part, you have a moſt abſolute and perfect Way of delineating *Sun Dials* upon all ſorts of *Plain Superficies* in what Poſition ſoever ſituate, and in any Latitude, whether the *Plains* be direct, or do decline, or whether they both decline and recline: And alſo you may there find, not only the manner how o make Dials, but to know the Grounds and

Reaſon of *Dials*, deduced from the Sphere or Globe projected *in plano*, upon the *Dial-plain*'s Superficies.

But notwithſtanding the Exactneſs and Rationality of delineating of *Hour-lines* upon all *Plains*, and in all Places, as is before taught; yet the ways there delivered, may (in ſome Caſes, at ſome Times) be found inconvenient to put in Practice: As (1) When the Centers of ſome of the *Circles* fall out to be very remote. (2) When the unequal Diviſions of the *Equinoctial Circle* come very near or cloſe together, which they will always do, when the *Pole* hath but ſmall Elevation above the *Plain*, and ſuch like. For the removal of which Inconveniences, I ſhall in this Second Part add another *Geometrical Way of Dialling*, which ſhall be both plain, eaſie, exact, and quick of Diſpatch; and all of it performed by ſtrait Lines, and not by Circular Lines, as the former Way requires. And moreover, this ſecond Way hath a Convenience, whereas moſt other *Geometrical Ways of Dialling* are liable to out-run the Limits of the *Plain*, by almoſt infinite Excurſions: For in this Way, having firſt made a preparative Scheme upon Paper (or Paſtboard rather) you ſhall have but very few Lines to draw upon the *Dial-plain* but the Hour-lines themſelves.

In this Second Way, I ſhall be brief, beginning firſt to ſhew how to deſcribe the Hour-lines upon *Upright Declining Plains*; referring the Delineation of Hours upon the *Horizontal full North*, *South*, *Eaſt*, and *Weſt Plains* (whether upright or reclining) till afterwards: And the reaſon for my ſo doing, will of it ſelf appear, when I ſhall come to treat of them. Wherefore to proceed.

* * *

SECTION I.

How to draw the Hour-lines upon an Upright South Plain declining from the South towards the Weſt 20 deg. in the Latitude of London, *51 d. 32 m.*

HAVING the Latitude of the Place, and the Declination of your *Plain* given, before you come to draw the Hour-lines upon the *Plain*, you muſt firſt draw your preparative Scheme as followeth.

I. *How to draw a* Preparative Scheme *ſuitable to any Declination in any Latitude. Pl.* 8. *Fig.* 1.

Firſt, With 60 deg. or the Radius of your Scale of Chords, deſcribe the Quadrant of a Circle A B D, extending the Side B A to C, ſo that A C be equal to A B: And then draw the Right Line D C.

Secondly, On the Point B, erect the Perpendicular B *m.*

Thirdly, Take 51 deg. 32 min. (the Latitude) out of your Line of Chords, and ſet them from B to F, and from D to G, and laying a Ruler from A to F and G, draw the two Lines F K, and G I.

Fourthly, From the point G, draw the Line G H, parallel to D A, or perpendicular to B A.

Fifthly, Take 20 deg. (the *Plain*'s Declination) out of your Scale of Chords, and ſet them from D to E, and through the Point E, draw the Line E L, parallel to D A.

Sixthly, With 60 deg. (or the Radius of your Scale of Chords) taken in your Compaſſes, ſet one Foot in the point D, and with the other deſcribe the Arch A O, which divide into three equal parts in the points P and Q, for the whole Hours, each of which three Hour-ſpaces A P, P Q, and Q O, divide into four equal Parts at * * *, * * *, * * *, for Halfs and Quarters of Hours. Which done, if you lay a Ruler to the point D, and the points P and Q, the Ruler will cut the Line A C in the points 2 10, and 1 11, and by theſe points the Line A C is divided into three unequal parts in the Points 3, 9, 2, 10, 1, 11 and 12, repreſenting four Hours. And if from D, you lay a Ruler over the ſeveral Spaces in the Hour-line A C into four unequal parts for Halfs and Quarters of Hours. And thus is your preparative Scheme ſo far finiſhed. Wherefore now let us proceed,

II. *To draw the Meridian, Stile, Subſtile and Hour-lines upon the Plain it ſelf.* Plate 8. *Fig.* 2.

Firſt, Upon your *Dial-plain* draw a right Line as S T, for the Meridian, and Hour-line of 12. Upon which, aſſign any convenient point, as R for the Center of your Dial; through which point R, draw the Line R W perpendicular to S T.

Secondly, Out of your preparative Scheme take the Line B K, and ſet it upon your *Dial-plain* from R to T; alſo, from the preparative Scheme take B I, and ſet it on your *Dial plain* from R to W, on the right Hand, becauſe the *Plain* declineth Weſt, and from T to V, make the rectangled *Parallelogram* R W V T on the Eaſt ſide.

Third

Thirdly, Out of the preparative Scheme take the Line L A, and ſet it upon the *Dial-plain* from T to X, and from W to ⊖, and draw the Lines R X for the Subſtilar Line, and R ⊖ for the Hour-line of Six, which draw quite through the Center R.

Fourthly, Out of your preparative Scheme, take the Line E L, and ſet it upon your *Dial-plain* from R to 12, and from X to Y, perpendicular to R X, and draw the Line R Y for the Axis (or Stile) of your Dial.

Fifthly, Out of your preparative Scheme, take the Line G H, and ſet it on your Dial-plain from R to Z, and draw the Line Z 6, parallel to W V, till it cut the Hour-line of Six in 6.

Sixthly, Make R 6 above the Center, equal to R 6 below the Center, and draw the two Lines 12 6, and 12 6.

Seventhly, Out of your *Dial-plain* take the Length of the Lines 12 6, and 12 6 ſeverally, and ſet them upon the preparative Scheme from B to *b*, and from B to *a*. And laying a Ruler from C to *a* and *b*, draw the Lines M C, and N C.

Laſtly, From the point A or 3, 9, take the neareſt Diſtance to the Line N C, and ſet that Diſtance upon your Dial-plain from 12 to 9, for it will (if you work truly) divide the Line 6, 12 into two equal parts in 9. Alſo ſet one Foot of the Compaſſes in the point 2, 10 in the Line A C of the preparative Scheme, with the other take the neareſt Diſtance to the Line N C, and ſet that Diſtance upon your Dial-plain, from 12 to 8, and from 6 to 10. —— Again, ſetting one Foot of the Compaſſes in the point 1, 11. in the Line A C of the preparative Scheme, with the other take the neareſt Diſtance to the Line N C, and ſet that Diſtance from 12 to 11, and from 6 to 7. So is the longer Line 6, 12 on your Dial plain, divided into 6 unequal parts in the points 7, 8, 9, 10, and 11; through which points, Lines drawn from the Center R, ſhall be the true Forenoon Hours.

For the Afternoon Hours, the ſhorter Line 12, 6. on your Dial-plain, muſt be divided from the Line M C in the preparative Scheme, as the longer Line 12, 6 was before divided; by taking the leaſt Diſtance from A or 9, 3 to the Line M C, and ſetting it from 12 to 3, or from 6 to 3. —— Alſo the leaſt Diſtance from 2, 10, to M C, in the preparative Scheme, will reach from 12 to 2, and from 6 to 4. —— Likewiſe the leaſt Diſtance taken from 1, 11, to the Line M C, in the preparative Scheme, will reach from 12 to 1, and from 6 to 5. So is the ſhorter Line 12 6, on the Dial-plain, divided into 6 unequal parts in the Points 1, 2, 3, 4, 5. Through which Points, and the Center R, right Lines being drawn, they ſhall be the true Hour-lines upon the Plain. And ſo is your Dial finiſhed.

If you would inſert the Halfs and the Quarters of Hours into your Plain, you may eaſily do it, if from the preparative Scheme you take the neareſt Diſtance from the Half and Quarter Points in the Line A C, and transfer them to the Lines 12, 6, and 12, 6, in the Dial-plate.

* * *

SECTION II.

How to deſcribe the Hour-lines upon the Horizontal, full South, North, Eaſt and Weſt, Erect or Reclining Plains. Plate 8. *Fig.* 3.

IN theſe kind of Plains, which directly behold the four Cardinal *North*, *South*, *Eaſt* and *Weſt* Points, the Latitude of the Place, and Reclination of the *Plain* being known, there is nothing required, but to know the Elevation, or Height of the Pole above the *Plain*, which how to find, is ſufficiently taught in the fourth and fifth Sections of the third Part of this Book: And therefore I ſhall not here mention the ſame again, but refer you to thoſe fore-mentioned fourth and fifth Sections of the Third Part hereof. Wherefore, to draw Hours upon any of theſe *Erect*, *Direct*, or *Direct Reclining Plains*, when the Height of the *Pole* or *Stile* above the *Plain* is found, you have no more to do; but,

Firſt, Draw a right Line A B for the Hour-line of Six, and another at right Angles thereto, for the Hour-line of 12, as the Line ⊙ X.

Secondly, With the Radius of your Line of Chords 60 deg. upon ⊙ as a Center deſcribe the Semicircle A X B. And the Height of the Pole above the Plain being known, (as for an Horizontal Dial for *London*, where the Pole is elevated 51 deg. 32 min.) Take 51 deg. 32 min. from your Chord, and ſet them upon the Semicircle from X to F, and from X to I, and through the Points F and I, draw the Lines 6 F and 6 I, parallel to ⊙ X, and

X, and draw the Lines X 6 and X 6 on either ſide of the Meridian.

Thirdly, (Having Recourſe to your former preparative Scheme) take in your Compaſſes the Length of the Line X 6, and ſet it upon the preparative Scheme from B to *c*, and laying a Ruler from C to *c*, draw the pricked Line C △.

Fourthly, In the preparative Scheme from the Point A or 9, 3, take the neareſt Diſtance to the Line △ C, and ſet it upon the Lines X 6, and X 6, from X to 3, and from X to 9. Alſo from the Point 2, 10, in the Line A C of the preparative Scheme, take the neareſt Diſtance to the Line △ C, and that Diſtance ſet upon the Lines X 6, and X 6, from X to 10 and 2, and from 6 to 8, and from 6 to 4. —— Likewiſe, take the neareſt Diſtance from the Point 1, 11, in the Line A C of the preparative Scheme, to the Line △ C, which Diſtance will reach from X to 11, and from X to 1, and alſo from 6 to 5, and from 6 to 7. So are the two Lines X 6 and X 6 divided each of them into ſix unequal parts, the one in the Points 1, 2, 3, 4 and 5, and the other in the Points 11, 10, 9, 8 and 7. Through which Points, right Lines drawn from the Center ⊙, they ſhall be the true Hour-lines proper for an Horizontal Dial, for the Latitude of *London*, 51 deg. 32 min.

FOR the Stile of this Dial, a Line drawn from the Center ⊙, through either of the Points F and I, ſhall repreſent the Axis of the World, or Stile of the Dial.

For

For a Vertical or Erect South Dial for the ſame Latitude 51 deg. 32 min.

THE Height of the Pole above a South Plain in the Latitude of 51 deg. 32 min. is 38 deg. 28 min. the Complement of the Latitude. Wherefore,

Firſt, Take 38 deg. 28 min. from your Scale of Chords, and ſet them from X to G, and from X to H, and draw the Lines G M and H L parallel to ⊙ X. Draw alſo X M and X L.

Secondly, Take the Length of the Line X M and X L, and apply it to your preparative Scheme, ſetting it from B to *d*, and laying a Ruler from C to *d*, draw another pricked Line C Æ.

Thirdly, The neareſt Diſtances taken from the Points A 2, 10, and 1, 11, in the Line A C of the preparative Scheme, will (being transferred from thence to the *Dial-plain*) divide the Lines X M and X L, each of them into ſix unequal parts, through which Diviſions, and the Center ⊙, Lines being drawn, they ſhall be the true Hour-lines of an *Erect South Dial* in the Latitude of *London*.

A Line drawn from ⊙ (the Center of the Dial) through the Points H or G, ſhall repreſent the Axis of the World, and be the Stile of this Dial.

For a Direct North Reclining Plain.

LET your Example be of a *Direct North Plain Reclining from the Zenith* 25 deg. and ſuch a *Dial* is deſcribed in the 17th Chapter of the Firſt Part, and the Height of the Pole or Stile above the Plain, was there found to be 63 deg. 28 min.

And ſo it will be found to be by the Rule delivered in the Fifth Section of the Third Part of this Book.

Firſt, The Height of the Stile being found to be 63 deg. 28 min. take 63 deg. 28 min. from the Scale of Chords, and ſet them from X to E, and from X to K, and draw the Lines E C and K D, parallel to the Meridian ⊙ X. Alſo draw the Lines X C, and X D.

Secondly, Take the Length of the Line X C or from X D, and ſet it upon the preparative Scheme from B to *e*, and draw a third pricked Line as *e* C.

Thirdly, The neareſt Diſtances taken from the Points A 2, 10, and 1, 11, in the Line A C, ſhall, (being ſet upon the Lines X C and X D) divide them each into ſix unequal parts, through which and the Center ⊙, right Lines being drawn, they ſhall be the true Hour-lines of a North Direct Plain Reclining 25 deg. in the Latitude of *London*.

THE Stile muſt be drawn from the Center ⊙, through the Point E or K.

For Direct Eaſt or Weſt Plains, whether Erect or Reclining.

FOR *Erect Direct Plains*, where the Hour-lines are parallel one to another, the Stile or Pole having no Elevation, the beſt Way to make them, is, as is directed in the ſixth Chapter of the Firſt Part. And therefore in this Place, nothing more need be ſaid concerning them. But,

For Eaſt and Weſt Recliners.

THE beſt Way to deal with theſe kind of *Plains*, is to refer them to a new Latitude, and to a new Declination in that new Latitude, both which are eaſily attained by this following GENERAL RULE.

1. *The new Latitude, is always the Complement of the old Latitude.*
2. *The new Declination in that new Latitude is the Complement of the Reclination.*

So that if a direct Eaſt Plain, in the Latitude of *London* 51 deg. 32 min. ſhould recline 40 deg. and you would find the new Latitude, and new Declination;

Firſt, The Complement of the old Latitude 51 deg. 32 min is 38 deg. 28 min. And that muſt be the new Latitude.

Secondly, The Reclination being 40 deg. The Complement thereof is 50 deg. And that is the new Declination.

So that if (by the Direction of the firſt Section hereof) you make an Erect Dial to decline 50 d. in the Latitude of 38 deg. 28 min. that Dial ſhall ſerve for an *Eaſt* or *Weſt Dial*, reclining 40 deg. in the Latitude of 51 deg. 32 min.

Thirdly, Although this Declining Plain be truly made, yet the placing of it upon the *Dial-plain* differeth from *Erect Plains*: For, in all Erect Declining Plains, the Hour-line of 12 is always perpendicular to the Horizontal Line of the Plain. So in all *Eaſt* and *Weſt* reclining Plains, the Hour-line of 12 muſt lie parallel to the Horizontal Line of the Plain. As you may ſee in the *Figure* Chap. 10, of Part the Firſt.

IT may here be expected, that I ſhould ſay ſomething concerning *Declining Reclining Plains*, which this Geometrical Way will very well perform by referring them to a new Latitude and a new Declination, where they will become *Erect Declining Plains*; but there are three Ways in this Book already taught, how to effect the ſame by other Means. I thought good to omit them in this Place; and to give Examples in Erect Direct, in Direct Reclining, and in Erect Declining Plains (as being of all others the muſt uſeful.) And ſo I ſhall conclude this *Second Geometrical Way of Dialling*.

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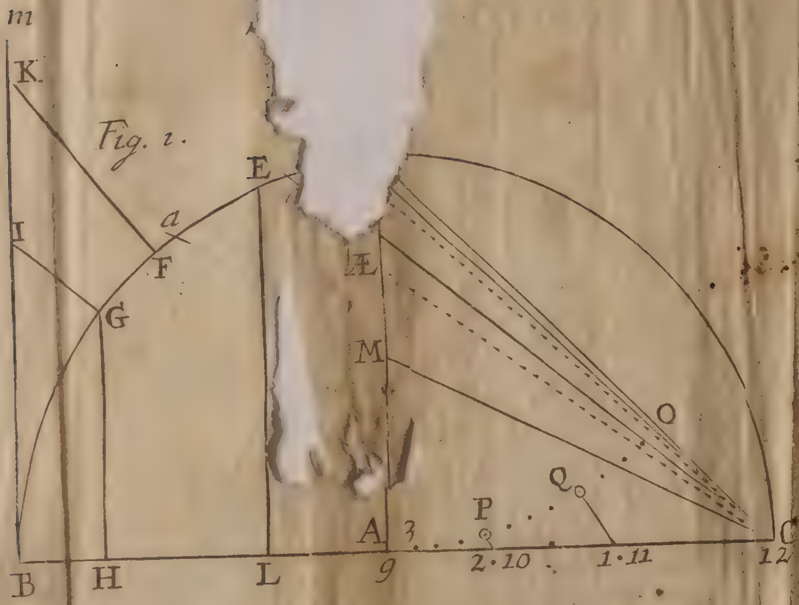


Fig. 1.

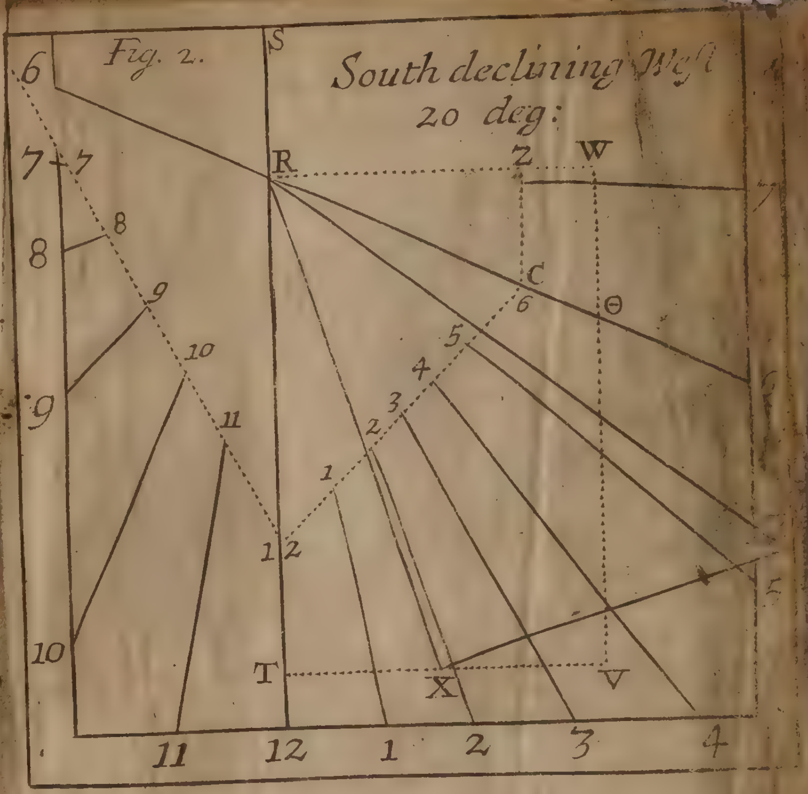


Fig. 2.

South declining West 20 deg:

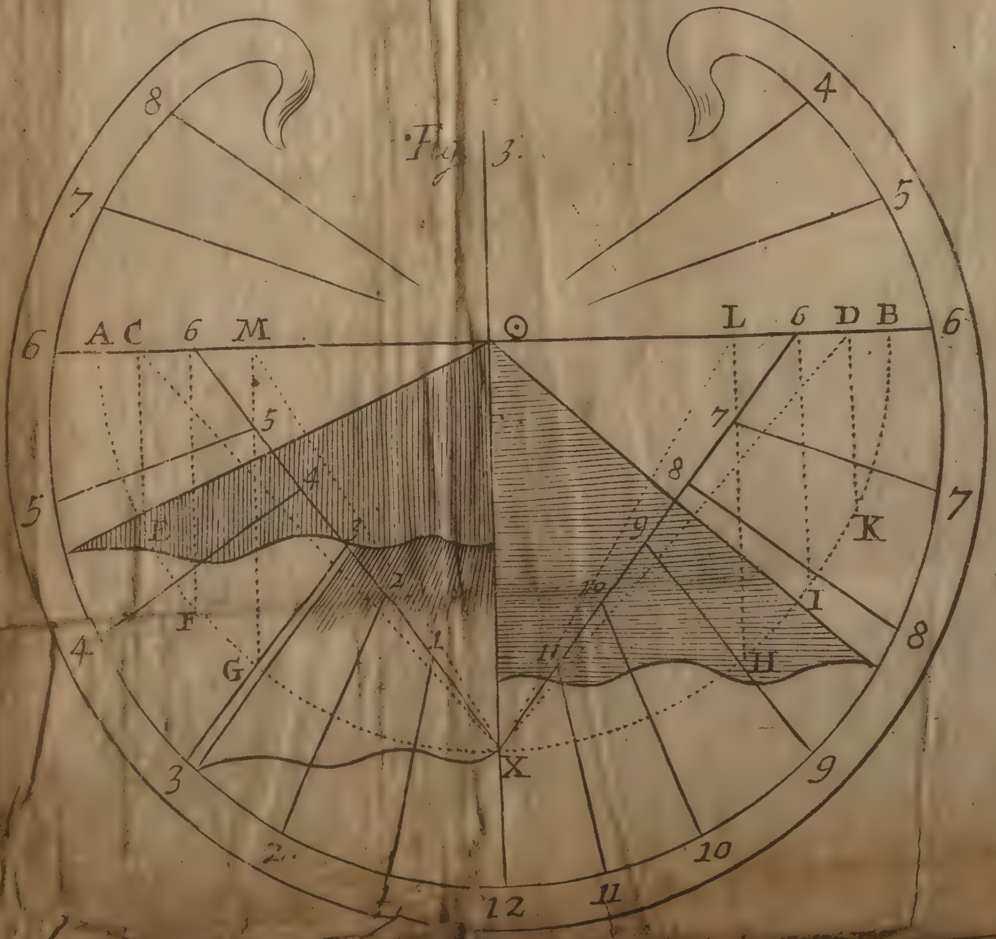


Fig. 3.

The ART of
DIALLING,
Arithmetically Performed:
By the *CANONS* (or *TABLES*) of Artificial *Sines* and *Tangents*.

PART III.

The Argument.

WHEREAS the two foregoing *Geometrical* Ways, of delineating or making of *Sun-Dials*, may be rejected by ſome, and a more accurate Performance of the ſame required by others, thought good, (to make this Treatiſe the more ompleat, which for a *Geometrical* Way is already erfect enough) to add the Canons, Analogies, or

Proportions, by which the ſeveral Requiſites in all *Plains* may be *Arithmetically* attained, by the Help of the Canons or Tables of Artificial Sines and Tangents (than by which there can be no exacter Way.) Which Tables are already in moſt Mens Hands, and the general Uſe of them no leſs common: Wherefore I ſhall ſay nothing of that in this Place, but proceed to the finding the 'forementioned Requiſites, as followeth. And,

SECTION I.

Of Vertical or Horizontal Plains.

IN theſe *Plains* there is nothing required but the Height of the *Pole* above the *Plain*, which in all Places is equal to the Latitude of the Place, for which the Dial is to be made.

SECTION II.

Of North and South Erect Direct Plains.

IN theſe Plains alſo there is nothing required but the Height of the *Pole* above the *Plain*, which in all Places is equal to the Complement of the Latitude of the Place. Wherefore, ſubtract the Latitude of the Place, for which your Dial is to be made from 90 deg. and the Remainder is the Height of the Pole above the outh or North Erect Direct *Plain.*

	deg.	min.
From	90	00
Subſtract Latitude	51	32
There remains	38	28

Which is the Height of the *Pole* above a Diect North or South *Plain* in the Latitude of 1 deg. 32 min.

SECTION III.

Of North and South Erect Declining Plains.

BUT in Erect Declining *Plains*, (beſides the Latitude of the Place, and the Declination f the *Plain*) there are three Things requiſite to found, before you draw the Dial, and they e,

1. *The Height of the Stile (or Pole) above the Plain.*
2. *The Diſtance of the Subſtile from the Meridian.*
3. *The Plain's Difference of Longitude.*

Example, In the declining *Plain* in *Chapter* 8, whoſe Declination was 24 deg. 20 min. in the Latitude of 51 deg. 32 min.

1. *For the Height of the Pole above the Plain.*

As the Radius 90 deg. 10.00000

Is to the Co-ſine of the Latitude 38 deg. 28 min. 9.79383

So is the Co-ſine of the Declination 65 deg. 40 min. 9.95959

To the Sine of 34 deg. 33 min. 9.75342

Which 34 deg. 33 min. is the Height o the Pole above the *Plain.*

2. *For the Diſtance of the Subſtile from the Meridian.*

As the Sine of 90 10.00000

Is to the Sine of the *Plain*'s Declination 24 d. 20 m. 9.61494

So is the Co-Tangent of the Latitude 38 d. 28 m. 9.90008

To the Tangent of 18 d. 8 m. 9.51503

Which 18 deg. 8 min. is the Diſtance of th Subſtile from the Meridian.

3. *For the Plain's Difference of Longitude.*

As the Co-ſine of the Latitude 38 d. 28 min. 9.7938

Is to the Radius 90 deg. 10.0000

So is the Sine of the Diſtance of the Subſtile from the Meridian 18 deg. 8 min. 9.4930

To the Sine of 30 deg. 01 min. 9.6991

Which 30 deg. 01 min. is the *Plain's* Dif rence of Longitude.

S E

SECTION IV.

Of South Direct Reclining Plains.

IN theſe *Plains*, (the Latitude of the Place, and the Reclination of the Plain being given) there is only required the Height of the *Pole* above the *Plain*: In which there are three Caſes, in all which you may find the Stile's Height, as followeth:

1. If the Reclination of the *Plain* be leſs than the Complement of the Latitude of the Place, ſubſtract the Reclination out of the Complement of the Latitude, and the Remainder will be the Height of the *Pole* or *Stile* above the Reclining *Plain*. But,
2. If the Reclination of the *Plain* be more than the Complement of the Latitude, ſubſtract the Complement of the Latitude from the Reclination, and the Remainder ſhall be the Elevation of the *Pole* above the *Plain*.
3. If the Reclination be equal to the Complement of the Latitude, the *Pole* hath no Elevation over ſuch a *Plain*, but is an *Equinoctial Plain*, and muſt be made by the Rules delivered in the twelfth Chapter of the Firſt Part of this Book.

		deg.	m.
1. Caſe	Latitude 51 deg. 32 min. Complement	38	28
	Reclination	22	10
	Height of the *Pole* above the *Plain.*	16	18
2. Caſe	Reclination	62	23
	Latitude 51 deg. 32 min. Complement	38	28
	Height of the *Pole* above the *Plain.*	23	55

SECTION V.

Of North Direct Reclining Plains.

IN theſe *Plains* alſo (the Latitude and Reclination being given) there is only required the Height of the *Pole* above the *Plain.*

To find this,

1. Add the Complement of the Latitude to the Reclination, and the Sum of them is the Height of the *Pole* above the *Reclining Plain.*

	deg.	min.
Lat 51 deg. 32 min. Compl.	38	28
Reclination	27	12
Height of the *Pole* above the *Plain.*	65	40

2. But if this Sum exceed 90 deg. then ſubtract it from 180 deg. and the Remainder ſhall be the Height of the *Pole* above the Plain.

	deg.	min.
Latitude 51 deg. 32 min. Compl.	38	28
Reclination.	70	42
Sum.	109	10
Which ſubtract from	180	00
There remains	70	50

Which 70 deg. 50 min. is the Height of the *Pole* above the *Plain.*

3. If the Sum of the Complement of the Latitude and the Reclination added together do make juſt 90 deg. then that *Plain* is a *Polar-plain*, and the Dial for ſuch a *Plain* muſt be made in all Reſpects as is directed in the 16th Chapter of the firſt Part of this Book.

SECTION VI.

Of Eaſt and Weſt Direct Reclining Plains.

In Eaſt and Weſt reclining Plains (the Latitude of the Place, and Reclination being given) there are required the ſame three Things as in North and South Erect Decliners, namely,

1. *The Height of the Pole (or Stile) above the Plain.*
2. *The Diſtance of the Subſtile from the Meridian.*
3. *The Plain's Difference of Longitude.*

Example, Of the Eaſt or Weſt reclining Plain, Part I. Chap. 10. whoſe Reclination was 35 d. 00 m. and Latitude 51 deg. 32 min.

1. *For the Height of the Pole or Stile above the* Plain.

As the Radius 90 deg.	10.00000
Is to the Sine of the Latitude 51 d. 32 min.	9.89374
So is the Sine of the Reclination 35 d.	9.75855
To the Sine of 26 deg. 41 min.	9.65233

Which 26 deg. 41 min. is the Height of the Pole above the reclining Plain.

2. *For the Diſtance of the Subſtile from the Meridian.*

As the Radius 90 deg.	10.00000
Is to the Tangent of the Latitude 51 deg. 32 min.	10.09991
So is the Co-ſine of the Reclination 35 deg.	9.9133
To the Tangent of 45 deg. 52 min.	10.0132

Which 45 deg. 52 min. is the Subſtile's Diſtance from the Meridian.

3. *For the* Plain's *Difference of Longitude.*

As the Sine of the Latitude 51 d. 32 m.	9.8937
Is to the Radius 90 deg.	10.0000
So is the Sine of the Subſtile's Diſtance from the Meridian 45 deg. 52 min.	9.8559
To the Sine of 66 deg. 27 min.	9.9622

Which 66 deg. 27 min. is the Plain's Difference of Longitude.

SECTION VII.

Of South and North Declining Reclining Plains.

IN Declining Plains reclining (beſides the Latitude of the Place, Declination and Reclination of the *Plain*; (which are for the moſt part given) there muſt four Things be found before you can draw the Dial, *viz.*

1. *The Diſtance of the Meridian and Horizon.*
2. *The Height of the Pole or Stile.*
3. *The Diſtance of the Subſtile from the Meridian.*
4. *The Plain's Difference of Longitude.*

Of theſe Plains you have in the 20, 21, 22, 23, 24, and 25 Chapters of the firſt Part, ſix Varieties, which are all that in any Caſe may happen, *viz.* Three of South Declining Reclining, and as many of North Declining reclining; I ſhall only inſtance in two of them, *viz.* one of a South reclining Plain Declining Eaſterly, and another of a North reclining Plain Declining Weſterly. The Example of the South Recliner ſhall be that in the third and laſt Variety of South Decliners reclining, and that is of a South Plain declining Eaſterly 30 deg. and reclining 55 deg. as in Part I. Chap. 22.

I. In South Decliners Reclining.

1. *For the Diſtance of the Meridian from the Horizon.*

As the Radius 90 deg. 10.0000

Is to the Sine of the Reclination 55 deg. 9.9133
So is the Tangent of the Declination 30 deg. 9.7614

To the Tangent of 25 deg. 19 min. 9.6748
Which 25 deg. 19 min. being taken from 90 deg. leaves 64 deg. 41 min. the Diſtance of the Meridian from the Horizon.

2. *For the Height of the Pole (or Stile) above the* Plain.

This will require two Operations.

1. As the Radius 90 deg. 10.0000

Is to the Sine of the Diſtance of the Meridian from the Horizon 64 deg. 41 min 9.9561
So is the Co-ſine of the Reclination 55 deg. 9.7585

To the Sine of 31 deg. 14 min. 9.7147
Which 31 deg. 14 min. being leſs than the Latitude 51 deg. 32 min. ſubtract it therefrom and there will remain 20 d. 18 m.

Ther

Then again ſay,

2. As the Sine of the Diſtance of the Meridian from the Horizon 64 deg. 41.	Co. Ar. 0.04385
Is to the Sine of the Arch laſt found 20 d. 18 m.	9.54025
So is the Co-ſine of the Declination 30 deg.	9.93753
To the Sine of 19 deg. 25 min.	9.52163

Which 19 deg. 25 min. is the Height of the Pole or Stile above the Plain.

Note, That if the Arch found at the firſt of theſe Operations be equal to the Latitude of the Place (as there it was leſſer, *viz.* but 31 deg. 14 min.) then the reclining Plain had been an Equinoctial Decliner, and muſt be made as by the Precepts delivered in the 20th Chap. of the firſt Part.

3. *For the Diſtance of the Subſtile from the Meridian.*

As the Co-Tangent of the Declination 30 d. Co. Ar.	9.76144
Is to the Sine firſt found in the laſt Proportion, *viz.* 31 d. 14 m.	9.71477
So is the Tangent of the Height of the Pole above the Plain 19 deg. 25 min.	9.54714
To the Sine of 6 deg. 3 min.	9.023348

Which 6 deg. 3 min. is the Diſtance of the Subſtile from the Meridian.

4. *For the* Plain's *Difference of Longitude.*

As the Sine of the Difference of the Arch firſt found, and the Latitude of the Place, *viz.* 20 d. 18 m.	9.540255
Is to the Radius 90 deg.	10.000000
So is the Sine of the Subſtile's Diſtance from the Meridian 6 d. 3 min.	9.023355
To the Sine of 17 deg. 42 min.	9.483100

Which 17 deg. 42 min. is the Plain's Difference of Longitude.

II. In North Decliners Reclining.

In all theſe Plains (as well as in South Recliners) four Things muſt be found (beſides the Latitude of the Place, and the Reclination of the Plain, which are commonly given) before the Dial can be drawn, and thoſe are the ſame as in South Recliners, *viz.*

1. *The Diſtance of the Meridian from the Horizon.*
2. *The Height of the Pole (or Stile) above the* Plain,
3. *The Diſtance of the Subſtile from the Meridian.*
4. *The* Plain's *Difference of Longitude.*

All theſe may be found by the following *Canons* or *Analogies*. And for an Example, I ſhall make uſe of the North Plain declining

Weſterly 60 deg. and reclining 54 deg. as in the laſt Example of North Recliners, Part I. Chap. 25.

1. *For the Diſtance of the Meridian from the Horizon.*

As the Radius 90 deg.	10.00000
Is to the Sine of the Reclination 54 d.	9.90795
So is the Tangent of the Declination 60 deg.	10.23856
To the Tangent of 54 deg. 29 min.	10.14651

Which 54 deg. 29 min. being taken from 90 deg. leave 35 deg. 31 min. And that is the Diſtance of the Meridian from the Horizon.

2. *For the Height of the Pole (or Stile) above the Plain.*

This alſo will require two Operations.

1. As the Sine of the Declination 60 d.	9.93753
Is to the Radius 90 deg.	10.00000
So is the Co-ſine of the Diſtance of the Meridian from the Horizon 35 deg. 31 min.	9.91059
To the Sine of 70 deg. 2 min.	9.97306

To this Sine of 70 deg. 2 min. add the Complement of the Latitude 38 deg. 28 min. the Sum will be 108 deg. 30 min. and this Arch (being above 90 deg.) take it from 180 deg. ſo there will remain 71 deg. 30 min.

2. As the Sine of the Arch firſt found 70 deg. 2 min. Co.Ar. 0.02694

Is to the Sine of the Reclination 54 deg. 0 min. 9.90796
So is the Sine of the Arch laſt found 71 deg. 30 min. 9.97695

To the Sine of 54 deg. 43 min. 9.91185
WHICH 54 d. 43 m. is the Height of the Pole or Stile above the Plain.

Note, That if the Arch firſt found, *viz.* 70 d. 2 m. had been juſt 90 d. the Plain then had been a polar declining Plain, the Subſtile and the Hour of ſix being the ſame, and muſt be made by the Precepts delivered in Part I. Chapter 23.

3. *For the Diſtance of the Subſtile and Meridian.*

As the Tangent of the Reclination 54 deg. *Co.Ar.* 9.86126
Is to the Sine of the Arch firſt found, *viz.* 54 d. 29 m. 9.91059
So is the Tangent of the Height of the Pole above the Plain 54 deg. 43 min. 10.15021

To the Sine of 56 deg. 42 min. 9.92206
WHICH 56 deg. 42 m. or rather the Complement thereof to 180 d. *viz.* 123 d. 18 m. is the Diſtance of the Subſtile from the Meridian, according as you pleaſe to account it, either from the North, or from the South.

4. *For the Plain's Difference of Longitude.*

As the Sine of the Height of the Pole above the Plain 54 d. 43 m.	9.91184
Is to the Tangent of the Diſtance of the Subſtile and Meridian 56 d. 42 m.	10.18251
So is the Radius 90 deg.	10.00000
To the Tangent of 61 d. 48 m.	10.27067

Which 61 deg. 48 min. is the Plain's Difference of Longitude counted from the North, or the Complement thereof to 180 deg. *viz.* 118 d. 12 m. is the ſame Difference of Longitude counted from the South.

SECTION VIII.

Of the Hour Diſtances upon the Plain.

HITHERTO you have in a general, plain and eaſy Method, (and of all others the moſt exact) delivered the Manner how to calculate the Requiſites belonging to all ſorts of Plains, whether *Direct*, *Reclining*, *Declining*, or both. It reſteth now, to find the true Hour-Diſtances one from another upon any of theſe *Plains*, and for that (for all Dials which have Centers) there is only one general Analogy or Proportion, and that is this, Having found the *Plain's Difference of Longitude*; ſay,

As the Radius or Sine of 90 deg.
Is to the Sine or Height of the Pole or Stile above the Plain.
So is the Tangent of each Hour's Diſtance (upon the Equinoctial) from the Subſtile.
To the Tangent of the ſame Hour's Diſtance upon the Plain counted from the Subſtile.

Now, (becauſe Examples do more confirm than barely Precepts) I ſhall by Precedent or Example make plain all that hitherto hath been delivered, and one ſhall ſerve inſtead of many, and that ſhall be in an upright or erect declining Plain, (which of all Dials are the moſt common and uſeful.) Suppoſe therefore,

In Latitude 52 deg. 40 min. *an erect Plain beholding the South, to decline Weſtward* 24 deg.

The Arithmetical Calculation.

By the Rules delivered in the third Section of theſe *Precepts*, you ſhall find,

1. *The Height of the Pole (or Stile) above the Plain to be* 33 *deg.* 38 *min.*
2. *The Diſtance of the Subſtile from the Meridian to be* 17 *deg.* 14 *min.* And,
3. *The Plain's Difference of Longitude to be* 29 *deg.* 15 *min.*

These Requiſites being thus attained, the next Thing is to find the Hour Diſtances upon the Plain, which may be done by the laſt foregoing Analogy.

BUT firſt, you are to conſider the Quantity of the *Plain*'s Difference of Longitude, which here in this Example, is found to be 29 deg. 15 min. And becauſe every Hour's Diſtance upon the Equinoctial is 15 deg. diſtance from the *Subſtile*, or Meridian of the *Plain*; ſo 2 Hours is 30 deg. Diſtance, and 3 Hours is 45 deg. Diſtance: This *Plain*'s Difference of Longitude being above 15 d. (which is one Hour's Diſtance) and leſs than 30 deg. (which is two Hours Diſtance) the Subſtile (the *Plain* declining Weſterly) muſt needs fall between the Hours of 1 and 2 in the Afternoon. Wherefore ſubtract 15 deg. (1 Hour's Diſtance) from 29 deg. 15 min. and there will remain 14 d. 15 min. the Equinoctial Diſtance of 1 a Clock from the *Subſtile*. Alſo from 30 deg. (which is two Hour's Diſtance) ſubtract 29 deg. 15 min. and the Remainder will be 00 deg. 45 min. for the Equinoctial Diſtance of 2 a Clock from the Subſtile. Having found the two Equinoctial Diſtances of the two next Hour-lines, on either ſide of the *Subſtile* (as of 1 and 2) the reſt are eaſily found by the continual Addition of 15 deg. and ſo is the Column of the Equinoctial Diſtances in the following Table made. Being thus prepared, the true Hour-diſtances from the *Subſtile* upon the Plain, may be eaſily attained by the foregoing Analogy. I will inſtance in one Hour's Diſtance for all, and give you the reſt in a Table: As,

Let it be required to find the Diſtance of one a Clock upon the Plain from the Subſtile, ſay,

As

As the Sine of 90 deg.	10.00000
Is to the Sine of the Height of the Stile 33 deg. 38 min.	9.74341
So is the Tangent of the Equinoctial Diſt. of 1 a Clock, *viz.* 14 d. 15 m.	9.40478
To the Tangent of 8 d. 0 min.	9.14819

WHICH 8 d. 0 m. is the Diſtance of the 1 a Clock Hour-line upon the Plain from the Subſtile. And in the ſame manner you may find the Diſtance of 2 a Clock to be 0 d. 25 m. Of 3 a Clock 8 d. 53 m. Of 4 a Clock 18 d. 14 m. and ſo the reſt, as in the following Table for every whole Hour. And if you deſire halfs and quarters of Hours, you muſt inſert them in the Column of Equinoctial Diſtances, allowing 7 d. 30 m. for half an Hour, and 3 d. 45 m. for a quarter, and ſo 15 d. for a whole Hour.

	Hours	Equinoctial Diſtances		True Hour Diſtances		
		deg.	min.	deg.	min.	
	VIII	89	15	88	39	
	IX	74	15	63	1	
	X	59	15	42	57	
	XI	44	15	28	21	
	XII	29	15	17	14	
	I	14	15	8	0	
Subſtil.	II	0	45	0	25	Subſtil.
	III	15	45	8	53	
	IV	30	45	18	14	
	V	45	45	29	37	
	VI	60	45	44	41	
	VII	75	45	65	22	

Thus have you the Arithmetical Calculation of the whole Dial; it now remains to ſhew how theſe Hour-lines are to be transferred from the Table to the Dial-plain, which is to be done as followeth.

The Geometrical Projection.

Firſt, (Upon your Dial-plain) draw an Horizontal-line A B, and perpendicular thereunto another Line C D, for the Meridian and Hour line of 12.

Secondly, Take 60 deg. out of your Line of Chords, and ſetting one Foot in C, with the other deſcribe the Semicircle E F G.

Thirdly, Becauſe the Diſtance of the Subſtile from the Meridian was found to be 17 deg. 14 min. Take 17 deg. 14 min. from your Line of Chords, and ſet them upon the Semicircle from F to H, and draw the Line C H for the Subſtile.

South Declining Weſt 24 *d.* Lat. 52 *deg.* 40 *min. Plate* 6. *Fig.* 5.

Fourthly, The Height of the Stile being 33 d. 38 m. ſet that Diſtance upon the Semicircle from H to K, and draw the Line C K for the Stile.

Fifthly, (Having Recourſe to your Table) take 18 deg. 39 min. out of your Line of Chords, and ſet them upon the Semicircle from H to 8, and draw the Line C 8 for the Hour-line of 8 of the Clock.

Laſtly from your Line of Chords, take the deg. min. below, and ſet the ſame upon the Semi-circle upon the Plain from H, to the hours, and draw the lines for the Hour-lines.

deg.	min.		
63	1	9	C 9
42	57	10	C 10
18	21	11	C 11
17	14	12	C 12
8	0	1	C 1
0	25	2	C 2
8	53	3	C 3
18	14	4	C 4
29	37	5	C 5
44	41	6	C 6
65	22	7	C 7

THUS is your Dial finiſhed, only the Stile, which muſt be ſet to hang perpendicularly over the *Subſtile*, making an Angle at the Center of the Plain 33 d. 38 m. equal to the Height of the Stile.

AND thus have you an Abſtract of the whole *Art* of *Dialling*, after the moſt exact and compendious Way of Performance ; others may be more expeditious, but none more exact.

SECTION IX.

IT will be to little Purpoſe to be thus curious in finding of the true Poſitions of the Meridian, Stile, Subſtile and Hour-diſtances in all Plains, as n the foregoing Precepts is delivered, unleſs alſo we be as ſevere or ſtrict in finding of the Site or Poſition of the *Plain*, upon which the Dial is to be nade. For what will it ſignify to make the Dial rue, and place it in a wrong Poſition? You are n the Geometrical Part of this Book taught how o find the Declination of any *Plain*, and for the inding of it, to attain the true Azimuth of the Sun is the chief Ingredient, and how to perform hat Geometrically, is there taught two Ways. But that the like Exactneſs may be in the Performance of this alſo, I ſhall in this Place (before I end) exhibit the manner of finding the Sun's Azimuth at any Time, and in any Place by Arithmeical Calculation.

Example, In the Latitude of 51 deg. 32 min. the Sun having 17 deg. 56 min. of North Declination, and his Altitude 35 deg. Let it be required to find his Azimuth.

Firſt, Add the Complement of the Latitude, he Complement of the Declination, and the Comlement of the Sun's Altitude all into one Sum, nd take the half thereof, from which half Sum ubtract the Complement of the Declination, and note the Difference as here is done.

	deg.	min.		deg.	min.
Latitude	51	32	Complement	38	28
Declination	17	56		72	04
Altitude	35	00		55	00
			Sum	165	32
			half Sum	82	46
The Difference between the half Sum and the Compl. of the Declination.				10	42

Then will the Proportion be.

(1.) As the Radius 90 deg.	10.00000
Is to the Co-sine of the Altitude 55 deg.	9.91336
So is the Co-sine of the Latitude 38 deg 28 min.	9.79383
To the Sine of 30 deg. 38 min.	9.70719
(2.) As the Sine of 30 deg. 38 min.	9.70719
Is to the Sine of the half Sum 82 d. 46 m.	9.99653
So is the Sine of the Difference 10 deg. 42 min.	9.26873
	19.26526
To this Sine	9.55807
To which add the Radius or *Sine* of 90 deg.	10.00000
The Sum is	19.55807
The half Sum	9.77903

WHICH is the Sine of 36 deg. 58 min. the Complement whereof is 53 deg. 2 min. and that doubled is 106 deg. 4 min. which is the Sun's Azimuth from the North Part of the Meridian, which if you take from 180 deg. there will remain 73 deg. 56 min. which is the Azimuth from the South. And thus may you find the Sun's Azimuth more exactly at any Time: Or more expeditiouſly thus,

OPERATION.

	deg.	min.
Co-Alt.	55	00
Co-Lat.	38	28
Difference	16	32
Half	08	16

	deg.	min.
Co-decli.	72	04
Half	36	02
½ + and −	08	16
Sum	44	18
Diff.	27	46

	deg.	min.		
Sine	55	00	Co-Ar.	0.086636
Sine	38	28	Co-Ar.	0.206168
Sine	44	18		9.844114
Sine	27	46		9.668266
			Sum	19.805184
Half is Sine	53 d.	2 m.		9.902592

Doubled is 106 d. 4 m. the Sun's Azimuth from the North, as before.

A

A
SUPPLEMENT
TO
Geometrical DIALLING, &c.

CHAP. I.

Of ſuch Circles of the Sphere, as are deſcribed upon Sun-dials.

MANY Aſtronomical Concluſions may be performed by deſcribing the Circles of the Sphere upon the *Dial-plains*; of which I have here made Choice of theſe following:

1. THE *Parallels* of the *Signs*, ſhewing what part of the *Zodiack* the Sun is in at all Times of the Year.

2. The *Diurnal Arches*, ſhewing the Length of the Day and Night throughout the Year.

3. The Hours from the *Sun's Riſing*, or *Setting*; or the *Babyloniſh* or *Italian Hours*.

4. The *Unequal*, *Jewiſh*, or *Planetary Hours*.

5. The *Azimuths*, or *Vertical Circles*, ſhewing in what Quarter of the World, or upon what Point of the *Mariner*'s *Compaſs*, the Sun is at all Times of the Day.

6. The *Almicanter*, or *Circles* of *Altitude*; whereby the Proportion of Shadows to their Objects, or the Sun's Height may be known.

Of theſe ſome are great Circles of the Sphere, others ſmall: The great Circles in all Plains are repreſented by ſtrait Lines, as the Hour-lines themſelves are: The leſſer Circles are deſcribed by Conick Sections; and they are either *Parabolas*, *Hyperbalas*, or *Ellipſes*: Only the Parallels of the Signs, and the Diurnal Arches in *Polar Dials*, and the Parallels of Altitude in *Horizontal Dials*, are perfect Circles.

CHAP. II.

How to deſcribe the Æquinoctial, the two Tropicks, and other intermediate Parallels of Declination, upon any Dial-plain.

THE two *Tropicks* being the Boundaries of the Sun's Courſe, (for he never exceeds thoſe Limits,) I count it beſt, firſt to ſhew how they may be deſcribed; for that between them all other Circles (either great or ſmall) muſt be projected, and the manner of deſcribing them upon ſeveral *Plains* is various.

In a *Polar Dial* they are perfect Circles, and ſo are eaſily deſcribed by Circles drawn about the Foot of the *perpendicular Stile*; in all other *Plains* they are Sections of a *Cone*.

I. *In the* Equinoctial *and direct Eaſt or Weſt Dials. Plate* 9.

Let an Example be of a direct Eaſt Dial, in the Latitude of 51 d. 32 m.

How to deſcribe the Hour-lines upon theſe Plains, is ſhewed in the 6th Chapter of this Book. Wherefore ſuch a Dial being drawn as in Figure I, through the Foot of the *Perpendicular Stile* at E, draw a right Line M,E,N, parallel to the Horizon; for the Horizontal Line in all Plains muſt be drawn through the Foot of the *Perpendicular Stile*, and alſo through the Point where the *Equinoctial Circle* croſſeth the Hour-line of Six. Your *Dial*, with the Equinoctial Line thereof H, E, S, being drawn, come we to deſcribe the *Tropicks*: To effect which,

Firſt, Upon a Piece of fine Card-Paſt-board, draw a right Line O R, as in Figure II. repreſenting the Equinoctial Lines in your Dial; and (becauſe the *Tropicks* are 23 deg. 30 min. diſtant from the Equinoctial) with 60 deg. of your Chords, upon the Point O, deſcribe an Arch of a Circle, and upon it ſet 23 deg. 30 min. from R to S, and draw the Line O S, repreſenting the two *Tropicks*; and this Angle S, O, R, I call a *Trigon*.

Secondly, Out of your Dial take the Length of the *Perpendicular Stile* E G, and ſet it upon the

Trigon from O to P, and draw the Line P 6 perpendicular to O R: Alſo,

Take the Diſtance from G, to the Interſection of the Hour-line of

7	with the Equinoctial, and ſet them upon the Trigon from O to	*q*	and draw the line	*q* 7	Perpendicular to O R.
8		*r*		*r* 8	
9		*s*		*s* 9	
10		*t*		*t* 10	
11		*v*		*v* 11	

Having thus prepared the Trigon, out of it take the Diſtance P 6, and ſet it upon the 6 a Clock Hour-line from E to *c*: —— Alſo take the Diſtance *q* 7, and ſet it upon your *Plain* from V to *b*, and from VII to *d*: — Alſo take *r s*, and ſet it on your *Plain* from IV to *a*, and from VIII to *e*: —— Likewiſe take the Diſtance *s* 9, and ſet it upon your *Plain* from IX to *f*: —— Alſo take the Diſtance 10 *t*, and ſet it from X to *g*: Laſtly, take *v* 11, and ſet it on the *Plain* from XI to *h*.

These Points *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, are the Points through which the Tropick of *Cancer* muſt be deſcribed; wherefore, if through them a Line be drawn with an even Hand, making no Angles, that ſhall be the Tropick of *Cancer*.

The Tropick of *Capricorn* may be deſcribed in the ſame manner, if for your Trigon you take

The Diſtance	8 *r*	And ſet it upon your Dial Plain from	VIII	to	*k*
	9 *ſ*		IX		*l*
	10 *t*		X		*m*
	11 *v*		XI		*n*

Thoſe ſhall be the Points through which the Tropick of *Capricorn* muſt be deſcribed; wherefore if through *k l m n*, a Line be drawn with an even Hand, it ſhall repreſent the Tropick of *Capricorn.*

AND whereas I ſaid before, that the two Tropicks are the Boundaries of the Sun's Courſe, you are to note, That

When the Sun is in

Capricorn,	which is about	*Dec.* 11.	the Shadow of the top of the *Stile* will paſs along thoſe reſpective Lines.
Aries,		*Mar.* 10.	
Libra,		*Sept.* 12.	
Cancer,		*June* 11.	

AND according to this Method may any other intermediate Parallels of Declination be inſerted; as for Example, Suppoſe I would inſert the Parallels of the Sun's Entrance into the 12 *Signs*, *Aries* and *Libra* are inſerted already, alſo *Cancer* and *Capricorn*; for the reſt, as when the Sun enters into

Taurus,	the Sun hath 11 deg. 30 min.	of Declination.
Virgo,		
Scorpio,		
Piſces,		
Gemini,	the Sun hath 20 deg. 12m.	
Leo,		
Sagittarius,		
Aquarius.		

WHEREFORE take 11 deg. 30 min. and 20 deg. 12 min. out of your Line of Chords, and ſet them upon the Arch R S of your Trigon, from R to V and X, and draw the two Lines O U and O X.

THESE *Parallels* being thus put into your Trigon, they may be transferred into the *Dial-plain*, in all reſpects, as the Tropicks were; and as you ſee done in the Figure I.

II. *In a direct North or South Dial.* Plate 9. *Fig.* 3.

HAVING drawn your Dial, as is taught in Chapter V. together with the Stile, your firſt Work muſt be to proportion your Stile to your Plain; which to do, aſſume any convenient Point in the Subſtile (here the Line of XII.) for the farthermoſt Tropick, as here the Point ♋; then the Stile's Height being 38 deg. 28 min. add 23 deg. 30 m. thereto, the Sum is 61 d. 58 m. and that is the Meridian Altitude of the Sun when he enters *Cancer*, and the Complement thereof 28 deg. 2 m. wherefore, upon the Point *Cancer*, make an Angle B ♋ A to contain 28 deg. 2 min. ſo ſhall the Line ♋ A cut the Axis of the *Stile* O A, in A; then from A let fall a perpendicular to O ♋, as A B; and ſo is your Stile proportioned to your Plain; and the Line C B D, (being drawn parallel to the Horizon, through the Point B) ſhall be the Horizontal-line of the *Plain*.

THIS done, prepare a Trigon, as Figure IV, in which make E F equal to O B, and E G, to A B, the Triangle E F G in the Trigon, equal to the Triangle of the Stile O A B in the *Dial*.

FROM the Point E draw a perpendicular to E F, as E 12, for the Equinoctial; and upon E, with 60 deg. of your Chord deſcribe an Arch H 12 L, and upon it ſet 23 deg. 30 min. from 12 to H and L, drawing the Line E H for the Tropick of *Cancer*, and E L for the Tropick of *Capricorn*.

Draw the *Subſtilar* Line F G quite throug the Trigon, croſſing the Equinoctial in *a*, and both the Tropicks.

This done, out of your Trigon take the Diſtance from F to *a*, and ſet it upon the *Dial-plai* from the Center O to *c*, through which Point draw the right Line ♈ *c* ♎ for the Equinoctial Then from O, the Center of your Dial, take the Diſtance to the Interſection of the *Hour-line* of 11 or 1 with the Equinoctial, and ſet that Diſtanc upon the Trigon from F to *b*: —— Alſo take th Diſtance from O, to the Interſection of the Hour-line of 10 or 2, and ſet it from F to *c*: —— Likewiſe the Diſtance from O, to the Interſectio of the Hour-line of 9 or 3, ſet from F to *d*: —— And laſtly, the Diſtance from O to the Interſection of 8 or 4, with the Equinoctial, ſet from to *e*; and draw the Lines F *a*, F *b*, F *c*, F *d*, *e*, through the Trigon, marking them with 12, 11 10, 9, 8, and 1, 2, 3, 4, &c.

Now to find the Points upon the Plain, thro which the Tropicks muſt paſs;

The Diſtance from F to

12	will reach				
11	from O,	♋	on the	12	
10	the Center	*f*	Hour-	11	1
9	of the Dial	*g*	line of	10	2
8	to	*h*		9	3

Through which Points the Tropick of *Cancer* muſt be drawn with an even Hand, And,

Th

The Diſtance from F to

12	will reach from O, the Center of the Dial, to	♑	upon the Hour-lines of	12	12
1		*k*		11	1
2		*l*		10	2
3		*m*		9	3
4		♑		8	4

Through which Points the Tropick of *Capricorn* muſt be drawn. And thus have you the *Equinoctial*, and the two *Tropicks* deſcribed upon a direct South *Plain.*

III. *How to deſcribe the Equinoctial, and the two Tropicks into any upright declining Plain; or into ſuch as both* Recline *and* Decline.

Our Example ſhall be in an Upright Plain, declining from the South Weſtward 30 deg. The making of theſe Dials is taught in the 7th and 8th Chapters of this Book: Wherefore, having drawn ſuch a *Dial*, with the *Stile* and *Subſtile* in a due Poſition, you ſhall find the Height of the Stile to be 32 deg. 36 min.

Firſt, Make an *Horizontal Dial* for the Latitude of 32 deg. 36 min. as in the *Declining Dial*, *Fig.* 5. where the Subſtilar-line is taken for the Hour-line of 12, as it is there marked, and the other pricked Lines, and the Hour-lines of an *Horizontal Dial* for the Latitude of 32 deg. 36 min. Now if according to the Directions of the foregoing *Section*, you make a *Trigon*, and inſert the *Equinoctial* and *Tropicks*; and afterwards expunge the obſcure Lines of the *Horizontal Dial*, the *Equinoctial*, *Tropicks*, and *Horizontal Line* will be the ſame, as f they had been inſerted from the Hour-lines belonging to the Plain.

AND as the *Tropicks* were deſcribed, ſo likewiſe may the Parallels of the Sun's Entrance into the other Signs, be inſerted, if into your Trigon you put the Arches of their Declinations from the Equinoctial, namely, 11 deg. 30 min. and 20 deg. 12 min. And ſo are the *Parallels* of the Signs put into this Dial, *Plate* 10. *Fig* 5.

AND in any Dial alſo may the *Diurnal Arches* be deſcribed, if you put into the Trigon ſuch Declinations, as the Sun hath from the Equinoctial, when the Day is either

♑		♋		deg.	min.
8	or	16	Hours long, as	23	30
9		15		21	40
10		14		16	55
11		13		11	37
12		12		5	55
				00	00

And ſo are the *Diurnal Arches* put into the South Plain, repreſented by the pricked Lines there, in Fig. 3. and the Trigon thereunto belonging. Fig. 4. both in Plate 9.

CHAP. III.

How the Hour-lines from the Sun's Riſing and Setting are to be inſcribed into all ſorts of Dial-plains.

THE Hour-lines from Sun-riſing are called the *Babyloniſh Hours*, for that they begin their Day at the Sun's Riſing; and the Hours from

Sun-ſetting are called the *Italian Hours*, for that they count their Time from the Setting of the Sun the Day preceding.

THE Manner how to inſcribe theſe Hours, is the ſame in all *Plains*, and is eaſily performed: And becauſe that upon a full *South*, or *Horizontal Plain*, they will appear moſt uniform; I have therefore made Choice of a direct South Dial, as is Fig. 3. Plate 9. to inſcribe them:

YOUR *Dial* being drawn, and the *Equinoctial* ♈ ♎, and the two *Tropicks* ♋ ♋, and ♑ ♑, and the *Horizontal Line*, *Sun riſe*, *Sun ſet*; you muſt (by the laſt Chapter) deſcribe two obſcure Parallels of Declination, one when the Day is 8 Hours long, as ☉ 8 ☉, and the other when the Day is 16 Hours long, as ✱ 16 ✱: The *Equinoctial* being the Parallel when the Day is 12 Hours long.

BEING thus far prepared, the Inſcription of theſe Hours will be very eaſie; for it is plain, that when the Day is but 8 Hours long, the Sun riſes at 8 in the Morning; and the firſt Line after the Sun's Riſing is 9 in the Morning:—— Alſo when he Day is 12 Hours long, the Sun riſes at 6 in he Morning, and the firſt Hour after is 7 in the Morning; —— Laſtly, When the Day is 16 Hours long, the Sun riſes at 4 in the Morning, nd the next Hour after is 5 in the Morning:—— And all the reſt as in the following Table.

❧

Hours from Sun Rising.	*Length of the Day.*		
	VIII	XII	XVI
I	9	7	5
II	10	8	6
III	11	9	7
IV	12	10	8
V	1	11	9
VI	2	12	10
VII	3	1	11
VIII	4	2	12
IX	5	3	1
X	6	4	2
XI	7	5	3

Wherfore a ſtrait Line drawn through the Interſections of theſe Hour-lines, with the Parallels of 8, 12, and 16 Hours, ſhall be the firſt Hour after the Sun-riſing all the Year long.

In like manner, if you would inſert the 7th Hour after the *Sun-Riſing*: By the Table you ſee that in the *Parallel* of VIII Hours for the Length of the Day, the ſeventh Hour from Sun-riſing is 3 in the Afternoon; therefore obſerve where the Hour-line of 3 croſſeth the Parallel of VIII Hours, which is at *a*. —— Alſo by the Table you ſee that in the *Parallel* of XII Hours, for the Length of the Day, the ſeventh Hour from *Sun-riſing* is 1 in the Afternoon; wherefore obſerve where the Hour-line of 1 croſſeth the *Equinoctial*, which is at *b*.— *Thirdly*, By the Table you ſee, that in the Parallel of XVI Hours for the Length of the Day, the ſeventh Hour from the Sun's riſing is 11 in the Forenoon; and therefore obſerve where the Hour-line of XI croſſeth the *Parallel* of XVI Hours for the Length of the Day, which is at *c*; ſo ſhall a right Line, drawn through theſe three Points *a*, *b*, *c*, be the ſeventh Hour after the Sun's Riſing throughout the Year: And thus by the Help of this little Table, may all the Hour-lines from the Sun's Riſing be drawn as you ſee them drawn and numbred, as in *Fig*. 3. *Plate* 9.

In the ſame Manner, as the Hours from the Sun's Riſing (which are the *Babyloniſh* Hours) were drawn, may the Hours from the Sun's ſetting, (which are the *Italian* Hours) be drawn: The Difference being only in numbering of them; the Hours from Sun riſing being numbered from the Weſt End of the *Horizontal Line*, by 1, 2, 3, 4, 5, 6, 7, 8, 9, 10: And the Hours from Sun ſetting from the Eaſt End of the *Horizontal-line* backwards, by 23, 22, 21, 20, 19, 18, 17, 16, 15, 14, 13; all which is evident in the fore-named Fig. 3.

COROLLARY.

The Hour-lines from Sun riſing and Sun ſetting being deſcribed upon any *Dial-plain*, as is before taught; there will by their correſpondent Interſections one with another, be points produced, hrough which if Lines be drawn with an even Hand, the ſame ſhall be the Parallels of the Length of the Day, and ſuch are the pricked Lines in Fig. 3, numbred upon the Meridian-line of the Dial, by 8, 9, 10, 11, 12, 13, 14, 15, 16.

CHAP. IV.

Of the Jewiſh, *or Old* Unequal, *or* Planetary-hours, *and how they may be inſcribed upon any* Dial-plain.

THE Ancients Account of their Day, was from the Sun's Riſing in the Morning, till its ſetting in the Evening, which Space of Time they did divide into 12 equal Parts, were it long or ſhort: So that in the Summer all that Time that the Sun hath North Declination, the *Hours* of their Day were longer than a common equal *Hour*; and in the Winter, when the Sun hath South Declination, the *Hours* of their Day were ſhorter than a common *Hour*; but when the Sun is in the *Equinoctial*, their *Hours* are equal to our common *Hours*.

THE Inſcription of theſe *Hour-lines* into all ſorts of Plains, is very eaſy, being much like the Inſcription of the *Italian* and *Babyloniſh* Hours, taught in the laſt Chapter.

The Jewiſh Hours.	The Parallel of 15 Hours.		Equi-noctial.	The Parallel of 9 Hours.	
	ho.	min.		Ho.	Min.
I	5	45	7	8	15
II	7	0	8	9	0
III	8	15	9	9	45
IV	9	30	10	10	30
V	10	45	11	11	15
VI	12	0	12	12	0
VII	1	15	1	0	45
VIII	2	30	2	1	30
IX	3	45	3	2	15
X	5	0	4	3	0
XI	6	15	5	3	45
XII	7	30	6	4	30

HAVING drawn your Dial with *Hours*, *Halfs*, and *Quarters*; and alſo the *Equinoctial*, the two *Tropicks* and *Horizontal* Line; and alſo the *Parallels* of the Length of the Day, as is done in *Fig.* 6. *Plate* 10. which is a South Dial declining Eaſtward 15 deg. you muſt make Choice of two *Parallels* of the Length of the Day, which muſt both of them be equidiſtant from the Equinoctial, which let be the Parallels of 9 Hours, and 15 *Hours*, for thoſe two Parallels are moſt convenient for this Purpoſe; becauſe the *Jewiſh Hours* in hoſe Parallels will juſtly fall upon the even *Hours*, *Halfs*, or *Quarters*: Now the Points thro' which he *Jewiſh Hours* are to be drawn, this Table will irect to; wherein you ſee, that the firſt *Jewiſh* *Hour* is to be drawn through 5 *Hours*, 45 min. in he Parallel of 15 *Hours*, through 7 in the Equinoctial, and through 8 *Hours* and 15 min. the Parallel of 9 *Hours.* —— In like manner the ſecond *Jewiſh Hour* muſt be drawn through the Interſection of the 7 *Hours* in the Parallel of 15 *Hours*, through 8 in the Equinoctial, and through 9 in the Parallel of 9 *Hours:* And ſo muſt all the reſt of them be deſcribed as the Table does direct, and as you ſee done in *Fig.* 5. And in this Manner, by help of this Table, may they be deſcribed in all ſorts of *Plains*, whether Direct, Reclining or Declining.

CHAP. V.

How the Azimuths or Vertical Circles are to be inſcribed upon Dial-plains.

THE Azimuths are great Circles, and being projected upon all Plains, become ſtrait Lines; and they are variouſly deſcribed, according as the *Plain* is ſituated. Particulars of which follow:

SECTION I.

On an Horizontal Plain.

IN theſe Plains the Azimuths are moſt eaſily inſerted: For, your Dial being drawn, with the *Tropicks* and *Equinoctial* thereupon, you have no more to do, than upon the Foot of the Perpendicular Stile at O (in Fig. 7.) as a Center, to deſcribe a Circle, as *S* ♋ *N* ♋, which you may divide into 32 equal Points (beginning at *N*) anſwering to the 32 Points of the *Mariner's Compaſs*, (or elſe you may divide it into 90 equal Parts or Degrees) noted with * * *, *&c.* and thro' thoſe Points draw ſtrait Lines from O, the Foot of the perpendicular Stile, and they ſhall be the true Azimuths upon the *Horizontal Plain*; which you may denominate by *South*, *S* by *E*, *S S E*, *S E* by *S*, *&c.* as you ſee done in *Fig.* 7. *Plate* 10.

SECTION II.

Upon an Erect, Direct Eaſt *or* Weſt Plain, Plate 9. Figure 1.

HAVING made an Eaſt Dial, and therein inſerted the Equinoctial, the two Tropicks, and the *Horizontal-line*, you may proceed to the Inſcription of the Azimuths in the manner following.

UPON the Point E, of the *Horizontal-line* of the Plain M, E, N, erect the Perpendicular E Q, equal to E G, (the Height of the Stile of your Dial) and upon Q, as a Center, deſcribe the Quadrant Q E L, and divide it into 8 equal Parts, repreſenting one Quarter of the Mariner's Compaſs, and from Q, through thoſe Points, draw Lines to the *Horizontal-line* M, E, N, noting them with ⊙ ⊙ ⊙ ⊙ ⊙ ⊙; from which Points let fall Perpendiculars from the *Horizontal-line*, and they ſhall be the Azimuths between the South and the Eaſt :— And for thoſe Points which fall between the Eaſt and the North; namely, *E* by *N*, —— *E N E*, ——*N E* by *N*,—— the ſame Diſtances being ſet upon the *Horizontal Line* from E, towards the left Hand, as the three firſt Azimuths, *E* by *S*, —— *E S E*, —— *S E* by *E*, were towards the Right Hand, ſhall give the three Points ⊙ ⊙ ⊙ on the Left Hand of E; through which Points alſo Lines drawn perpendicular to the Horizon, ſhall be the Azimuth or Points of the Compaſs between the Eaſt and the North: As in Fig. 1. And as the Eaſt Dial contains the Azimuths between the South and the Eaſt: The Weſt Dial muſt contain thoſe between the South and the Weſt.

SECTION III.

Upon a Direct South upright Plain. Plate 9. Fig. 3.

THE Dial, with the Equinoctial, the two Tropicks, and the Horizontal Line deſcribed thereon, the Azimuth may be inſerted thereon as followeth:

Firſt, Take the Length of the perpendicular Stile of your Dial A B, and ſet it upon the Meridian of your Dial from B to G.

Secondly, With the Diſtance G B, upon G deſcribe the Semicircle E B F, which divide into 16 equal Parts, (if you will) but I have here divided it but into 8, to ſhew the manner of the Work, in the Points * * * *, &c. through which Points from G, draw obſcure Lines, extending them till they touch the Horizontal Line of the *Plain* C B D; now if from theſe Points of touching, you draw Lines perpendicular to the Horizontal-line between the Tropicks, or parallel to the Line of 12, they ſhall be the Azimuths required.

I have not drawn the Lines themſelves in this Fig. 3. becauſe the Plain is full enough of Lines already.

SECTION IV.

Upon a South Declining Plain. Plate 10. Fig. 6.

AN Example ſhall be of a South Plain, declining Eaſtward 15 deg.

SUCH a Dial being drawn, and the *Equinoctial Tropicks*, and the Horizontal Line inſcribed thereon: Upon the Point B of the *Horizontal* Line erect the Perpendicular BC, equal to BO, the perpendicular Stile of your Dial; upon which point C deſcribe the Semicircle RBS; which done, lay a Ruler to C, and the point ⊙, where the Hour-line of 12 croſſeth the *Horizontal Line*, and where the Ruler cuts the Semicircle RBS, at that Point begin to divide it into 16 equal parts, at the Points * * *, &c. and from the Center C draw Lines through theſe Points, extending them till they touch the *Horizontal Line* DE in the Points *a b c d e f g h i k* and *l*; through theſe Points right Lines being drawn parallel to the Meridian, ſhall be the Azimuths deſired, which you muſt number according to the Situation of the Plain: Namely, the Weſtern Azimuths on the Eaſt Side of the Meridian, and the Eaſt Azimuths on the Weſt Side of the Meridian, as you ſee them numbred in Fig. 6. Plate 10.

CHAP. VI.

How to inſcribe the Circles of the Sun's Altitude into Dial-plains.

THE *Almicanters*, or Circles of Altitude, in the Sphere, have the ſame Habitude to the Azimuths, or Vertical Circles, as the *Parallels* of Declination have to the Meridians, or Hour-circles: And therefore, the *Equinoctial* it ſelf, and all the *Parallels* of Declination in a *Polar-plain*, are perfect Circles, and ſo are the *Almicanters* or Circles of Altitude upon an *Horizontal Plain*, as in Plate 10. Fig. 7.

Horizontal Plains, which lie parallel to the Horizon, have the Zenith for their *Poles*; ſo that for the Inſcription of them upon theſe *Plains*, the Foot of the perpendicular Stile muſt be the Center upon which to deſcribe them.

FOR the Numeration of theſe Circles, when they are deſcribed, there are two Ways moſt in Uſe: The one by Degrees and Minutes of the Sun's Altitude; the other according to the Proportion that the Height of any upright Object (as a Houſe, Steeple, *&c.*) bears to the Shadow of it: The laſt of which I have here followed in this Figure 7. where the Circles of Altitude are equal, double, triple, and quadruple to the Altitude of the perpendicular Stile.

THE Inſcription of theſe Circles into all other *Plains*, are, in a kind, the ſame with the Inſcription of the *Parallels* of Declination: Only, whereas as in inſcribing of the *Tropicks*, and other *Parallels* of Declination, you take the *Hour-lines* out of the *Dial-plain*, and put them into a Trigon; ſo in the Inſcription of theſe you muſt take the Azimuth Circles out of your *Plain*, and put them into a Trigon, and from thence transfer them back again to your *Plain*, as in the other: And as the *Hour-lines* in the other muſt be firſt drawn upon the *Plain*; ſo in this muſt the Azimuths be firſt inſcribed: And becauſe theſe Circles of Altitude are ſmaller Circles of the *Sphere*, as the Tropicks and Parallels of Declination were, they will upon all *Plains* (the *Horizontal* excepted) be *Conick* Sections.

* * *

CHAP VII.

A general and eaſy Way to project Hour-lines upon all kind of Superficies, without any Regard had to their ſtanding, either in Reſpect of Declination, Reclination or Inclination.

IF a Point be aſſigned upon any Superficies, flat, or curved, one or more, wherein the *Hour-lines* and *Axis* ſhall concur; how to project the Hours to that Point, and to ſet up an *Axis* after the ordinary Manner, to give Shadow to them, without any Knowledge how the Dial ſtandeth in reſpect either of Reclination, Declination, or Inclination.

Firſt, To the *Point* aſſigned (upon any Side of it) by the help of a Semicircle, or other Level, ſtretch out an Horizontal Thread, ſerving for the

Horizontal-line; which Line need not be one ſingle Line, but may be turned at one or more Angles, provided that it lie (all the parts of it) totally in the Superficies of the *Horizon*.

Secondly, With a perpendicular Thread held up, project the Sun upon the aſſigned Point, and into the *Horizontal* Thread, and ſtick in a Pin, or make a Mark upon the ſame *Horizontal-line*, thro' which the Shadow cutteth, and at the ſame Inſtant alſo take the Sun's Altitude.

Thirdly, By the Altitude taken find out the Sun's Azimuth; this Azimuth, whatever it be, is repreſented by the Mark formerly made in the *Horizontal-line* or Thread.

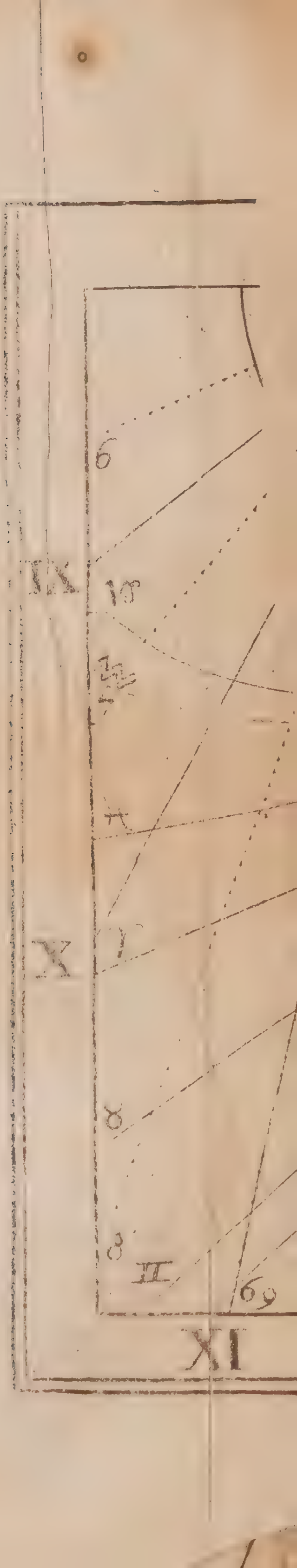
Fourthly, Apply a *Paſt-board* to the aſſigned Point, and hold it flat, that it may anſwer to the *Horizontal Thread* alſo; and upon this *Paſt-board* protract your Azimuth by a Thread extended from the Point aſſigned for the Center to the Mark upon the Horizontal Thread. Which done,

Fifthly, By help of that Azimuth upon the *Paſt-board*, protract the Meridian-line, obſerving the true Coaſt and Quantity of the Angle from the Azimuth; and to the Meridian thus found, deſcribe an Horizontal Dial for the place.

Sixthly, Apply the *Paſt-board* to its place again, all things ſtanding right as before; project all the Hours into the *Horizontal Thread* from off the *Paſt-board*, and ſet Marks upon the ſame Line, for the point of each ſeveral Hour, which Marks may be little Knots to ſlip to and fro upon the ſame Thread.

Seventhly, Project the *Meridian Point* by a perpendicular Thread upon ſome Object into that place whereabouts you imagine the Axis of the World would paſs, above or below, from the point aſſigned for the Center.

Eighthly,


6
IX
♑
♒
♓
X
♈
♉
8
♊
♋
XI

Eighthly, With your Semicircle, (or a String and Quadrant) elevated or depreſſed, (as it ſhall be required) from the point aſſigned for the Center, according to your Latitude, project the *Pole* of the World.

Ninthly, Extend a Thread from the *Point* aſſigned for the Center to the *Poles* of the World, which ſhall repreſent the *Axis*.

Tenthly, By the *Point* upon the Horizontal Thread, and this *Axis*, (either by your Eye, laying the *Axis* to the Hour-points, or laying the Hour-knots to the *Axis*,) you may project all the Hours, and draw them : ——— Or elſe you may let the *Axis* alone, and content your ſelf with the *Pole-point* projected into the Meridian : For if from the *Point* aſſigned to be the Center, or Meeting of the *Hours* and *Axis* you extend a Thread to each *Hour-point* in the Horizontal-line, and do repoſe (with your Eye) the ſame Thread upon the *Pole-points*; then ſhall the Shadow of the Thread give you that Hour-line; and do ſo in all the reſt.

Eleventhly, Your Thread or *Axis* lying in its true Situation, you may eaſily fit an Axis to the ſame Poſture. If your Dial be deſcribed upon a plain Superficies, you may then (by one ſide of a Square, applied to the Thread or *Axis*, and the other ſide lying upon the *Plain*) find out the Subſtile, and meaſure from it the Elevation of the *Plain*. ——— But if the Dial be deſcribed upon a curved Superficies, you muſt be content to ſet up your *Axis* by the Direction of the Thread only.

Twelfthly, This *Point* aſſigned for the Center, being a *Point* of the *Axis*, is, as it were, the *Apex* of the *Gnomon*, unto which all the Work is projected : But if it be required to ſet up an *Axis* to ſuch a Superficies, upon which the Hours and *Axis* wil not meet in any tolerable manner, becauſe perhaps the *Axis* may be but of a very ſmall Elevation above the Superficies, and yet an *Axis* is required, in this Caſe ſet up any point (of wire, or ſuch like) of ſuch Diſtance from the Superficies, as that the *Hours* and *Axis* may be diſtinct, and through that point let it be required to make the *Axis* paſs; you have no more to do but only to project to this point as before, by letting the Shadow of a perpendicular Thread paſs through that point, and noting the ſame upon the *Horizontal Thread*, and counting that End of the Wire as your Center, proceed as before; for the Thread that lies to project the Hours is a Pattern for the *Axis*.

THIS Way is general, ſerving to project the Hour-lines upon many Superficies, be they plain or curved, and however ſituate, whether contiguous or ſeparate, and that without any laborious Inquiſition after any of their Situations in reſpect of Declination, Reclination or Inclination.

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CHAP. VIII.

How from a Glaſs Horizontally placed, to reflect Hours upon any Superficies, flat or curved, one or more.

FIRST, The Glaſs being placed truly *Horizontal*, obſerve the Spot of Light that the Sun caſts, and make a Mark at it.

Secondly, And obſerve immediately the Sun's Altitude, and find the Azimuth.

Thirdly, Then extend an Horizontal Thread in the ſame Level with the Glaſs, but within the Room.

Fourthly, Project the Azimuth into the *Horizontal Thread*, by holding up a *Perpendicular* Thread in ſuch a place, that tho' it hang at Liberty, you may at once diſcern both the Mark of the Spot of Light, and the Glaſs likewiſe; and then obſerve where the perpendicular Thread ſeems to cut the *Horizontal Thread*, and at that apparent Interſection make a Mark upon the Horizontal Thread for the Azimuth.

Fifthly, Apply a *Paſt-board* to the Glaſs, ſo that it may be ſtayed upon ſome Reſt, that after it is taken away, it may be reſtored into its place again with all Exactneſs: Let it be alſo placed *Horizontally*, ſo that it may have full Relation to the *Horizontal* Thread.

Sixthly, At the Glaſs's Center make a Point for the Center upon the *Paſt-board*, and extending a Thread from the Center of the *Paſt-board* to the

Mark of the *Azimuth* upon the *Horizontal* Threa draw upon the *Paſt board* that Line, which the e tended Thread Figures out thereupon ; afterward unto the ſame Azimuth upon the *Paſt-board* draw Meridian Line, and to it an Horizontal Dial ; an applying the *Paſt-board* again to its firſt Situatio project the Hours thereon unto the Horizonta Thread, and there make Marks or Knots.

Seventhly, Then project the Meridian (by perpendicular Thread, covering in Appearance bot the Knot at 12, and the Glaſs) unto the contrar Coaſt to that, wherein the *Pole* is elevated abov the Horizon ; that is to ſay, in our Northern Climates, you muſt project the Meridian Southwar from the Glaſs, becauſe the North *Pole* is elevated : And in the Meridian elevate your Semicircle or extend a Thread and Quadrant from the Glaſ Southwards, till the *Plummet* falls upon your Latitude, ſo ſhall it point out upon ſome Object ſe to receive it, the North *Pole* reflected.

> Or elſe, if this be not convenient, (becauſe i Windows, which look towards the South the North Pole will be without the Room (and ſo the *Axis* above the Glaſs extended towards that *Pole* will be without alſo) yo may in ſuch Caſes find out the oppoſite *Pol* to it, that is to ſay, that *Pole* which the former reflected *Axis* being extended through the Glaſs, and below it, would ſign out, and that may be effected in this Manner.

Eighthly, Project the Meridian Line towards the *Pole* that is elevated, that is with us, towards the North *Pole* ; and then (becauſe the North *Pole* is elevated by Reflection towards the South, ſo, by the ſame Reaſon, the South *Pole* muſt be depreſſed towards the North) by your Semicircle, or String and Quadrant, directed even with the Center of the Glaſs, expreſs or project your Latitude downwards, (but towards the North) ſo ſhall the Semicircle or Thread point out the reflected South *Pole* in the Meridian. Now, whether you will, or can (moſt conveniently) uſe the reflected South *Pole* below it, you are to take your Choice, for both the one and the other of them do repreſent the reflected *Axis* of the World.

Ninthly, By this reflected *Azis*, and the Hour-points ſigned out upon the Horizontal Thread, you may eaſily project the reflected Hours, upon any kind of Superficies, one or more, whatever they be, that ſtand in the Way.

Geometrical DIALLING,

CHAP. IX.

How to make a plain Dial (either South or Horizontal) that ſhall give you the Hour of the Day at any Place or Places aſſigned, as well as at the Place the Dial is made for, according to the Engliſh *Way of reckoning.*

FIRST, Make a common plain Dial either South or Horizontal, as you would have your Dial to be; only in this Caſe it is beſt to place the Hours in a Circular Form, as you ſee it done; then (beſides the two Circles, between which the Hours are placed) draw ſo many Concentrick Circles as you would have Places in the Dial, and behind the Stile in each Circle put the Name of the Place whoſe Hour it repreſents; then obſerve what Difference of Longitude the Places propoſed have from *London*, and by allowing 15 Degrees for an Hour, place the Hours with ſo much Difference as the Difference of Longitude requires, the Shadow

Plate 11. *Fig.* 1.

dow ſhall give the true Hour at any of the Places propoſed. But becauſe in this Caſe a Table of Latitude, *&c.* of Places is neceſſary, I ſhall inſert the moſt correct Table of that Kind now extant, an Example of each of the above-mentioned Dials.

A Correct TABLE of the Latitudes and Difference of Meridians from *London*, of the moſt eminent Places in the World, moſtly corrected by Celeſtial Obſervations.

Names of Places.	Latit.		Diff. Merid		
	D.	M.	H.	M.	
Acapulca in *Mexico*	17	30	7	5	W
Agra, the *Mogul's* Court	28	30	5	33	E
Aleppo in *Syria*	37	20	2	25	E
Alexandria in *Egypt*	31	7	2	12	E
Amſterdam in *Holland*	49	54	0	9	E
Amiens in *France*	52	21	0	19	E
Antwerp in *Brabant*	51	10	0	17	E
Avignon in *France*	43	51	0	18	E
Babylon in *Chaldea*	34	30	3	15	E
Barbadoes	13	30	3	53	W
Barcelona	41	26	0	10	E
Batavia in *Sumatra*	6 S	15	6	43	E
Bayon	43	29	0	6	W
Bengal in *India*	21	56	6	21	E
Bergen in *Norway*	61	0	0	32	E
Bononia in *Italy*	44	30	0	47	E
Boſton in *New-England*	42	25	4	42	W
Breſt in *France*	48	23	0	18	W
Bourdeaux in *France.*	44	50	0	2	W

Cadiz

Names of Places.	Latit. D.	Latit. M.	Diff. Merid H.	Diff. Merid M.	
Cadiz in *Spain*	36	16	0	30	W
Calais in *France*	50	57	0	7	E
Camboia in *Italy*	10	20	7	12	E
Canea in *Crete*	35	29	1	37	E
Candia	35	18	1	41	E
Cape *Bona Eſperance*	34 S	15	1	4	E
Cape *Comerin*	8	0	5	13	E
Cape *Verde*	14	43	1	9	W
Cayen in the *Weſt Indies*	4	56	3	26	W
Cayro	30	4	2	17	E
Ceylon	7	50	5	33	E
Cheuſan in *China*	30	0	8	6	E
Cockin in the *Eaſt Indies*	9	25	5	3	E
Conimbra in *Portugal*	40	30	0	39	W
Conſtantinople	41	7	2	7	E
Copenhagen in *Zealand*	55	40	0	50	E
Corvo	40	3	2	6	W
Cracow in *Poland*	50	10	1	18	E
Cuſco in *Peru*	12 S	25	4	55	W
Dantzick in *Poland*	54	22	1	16	E
Diep in *Normandy*	49	56	0	4	E
Dublin in *Ireland*	53	12	0	28	W
Dunkirk in *Flanders*	51	1	0	9	E
Durazzo in *Dalmatia*	41	58	1	21	E
Edinburgh in *Scotland*	55	57	0	12	W
Embden	53	5	0	30	E
Fero Iſlands	28	5	1	13	W
Fez in *Barbary*	33	10	0	24	W
Florentia	43	41	0	47	E
Frankfort	50	4	0	33	E
Geneva	46	22	0	26	E
Genoa	44	27	0	39	E
Ghent in *Flanders*	51	1	0	15	E

Names of Places.	Latit. D.	M.	Diff. Merid H.	M.	
Goa in *India*	15	30	4	55	E
Goes in *Zealand*	51	30	0	16	E
Guardaloupa	14	0	4	9	W
Greenoble	45	16	0	24	E
Hamburgh	53	41	0	42	E
Haver-de-grace	49	30	0	1	E
Heydelburgh	49	20	0	36	E
Hoaignan in *China*	33	35	7	56	E
Jamaica Port Royal	17	40	5	4	W
Jeruſalem	31	22	2	28	E
Ingoldſtad	48	40	0	46	E
Inſpruck	47	15	0	47	E
Kebrock in *New France*	47	0	4	40	W
Koningsberg in *Pruſſia*	54	43	1	22	E
Leghorn	43	18	0	51	E
Leige	50	40	0	24	E
Leipſick	51	19	0	53	E
Lima in *Peru*	12 S	20	5	24	W
Lintz in *Auſtria*	48	16	1	0	E
Lions in *France*	45	45	0	20	E
Lisborn in *Portugal*	38	50	0	42	W
LONDON	51	32	0	0	
Macao in *China*	22	13	7	44	E
Madagaſcar	19 S	29	2	58	E
Madrid in *Spain*	40	10	0	13	W
Majorca	39	35	0	10	E
Malacca Iſlands	2	42	6	40	E
Martinico	14	44	4	4	W
Marſeilles	43	20	0	22	E
Meſſina in *Sicily*	38	21	1	6	E
Mexico	20	6	6	49	W
Montpellier	43	36	0	15	E
Moſcow	55	34	2	35	E

Namur

Names of Places.	Latit.		Diff. Merid		
	D.	M.	H.	M.	
Namur	50	25	0	20	E
Nangaſach in *Japan*	32	53	8	31	E
Nancy in *Lorrain*	48	39	0	27	E
Nantz	47	13	0	6	W
Naples in *Italy*	41	5	1	3	E
Narbonne	43	15	0	9	E
Narſinga	18	15	5	43	E
Nice, *Provence*	43	38	0	29	E
Ningpo, or *Liampo* in *China*	29	58	8	1	E
Noremberg	49	29	0	49	E
Olinda or *Pernambuck*	7	48	2	20	W
Oxford	51	44	0	5	W
Ozaca in *Japan*	35	5	8	52	E
Padua in *Italy*	45	31	0	45	E
Paris in *France*	48	50	0	9	E
Pekin in *China*	39	55	7	51	E
Poudicherri	11	54	5	21	E
Prague in *Bohemia*	50	40	0	58	E
Ratisbon	48	59	0	49	E
Reggio in *Italy*	42	15	0	55	E
Rhodes in *Germany*	36	42	2	12	E
Rochel	46	10	0	5	W
Rome	41	51	0	52	E
Roſtock	54	10	0	51	E
Rotterdam	51	55	0	17	E
Salamanca in *Spain*	41	12	0	16	W
Seville	37	36	0	26	W
Siam in *India*	14	18	6	43	E
Smyrna	38	28	1	49	E
Spahan in *Perſia*	36	14	4	20	E
Stockholm in *Sweden*	58	50	1	10	E
Syracuſe in *Sicily*	37	4	1	1	E
Tangier	35	55	0	25	W

Names of Places.	Latit.		Diff. Merid		
	D.	M.	H.	M.	
Tidore	0	36	6	37	E
Toledo in *Spain*	39	46	0	14	W
Toulon in *France*	43	6	0	23	E
Tripoly in *Barbary*	32	54	0	52	E
Tubing in *Germany*	48	34	0	37	E
Valencia in *Spain*	39	30	0	3	W
Venice	45	18	0	50	E
Vienna	48	22	1	9	E
Upſal in *Sweden*	59	0	1	12	E
Uraniburg	55	54	0	51	E
Utrecht	52	5	0	20	E
Wittenburgh in *Saxony*	51	53	0	52	E
Wolfembuttle	52	11	0	44	E
York.	54	0	0	4	W

NOTE, In the Column of *Latitudes*, where S is placed it is South *Latitude*, and all the reſt are North.

I ſhall now proceed to apply the foregoing Directions to Practice, and ſhall inſtance firſt in a Horizontal Plain Dial, which ſhould be required to give the Hour of the Day at *London*, *Mexico*, and *Jeruſalem*.

Firſt, Draw a Horizontal Dial by the Directions given Chap. 3. *Of Geometrical Dialling*, Page 37. which reduced to a Circular Form, will appear as in *Plate* II. *Fig.* 1. where the middle Circle of Figures repreſents a Dial for the Meridian of

London, then within that Circle of Figures draw the Concentrick Circle a b c d for *Mexico*. Alſo with it draw the Circle e f g h for *Jeruſalem*, (or you may draw them both within or both without, but the other is more proper, becauſe one Meridian is Eaſt, the other Weſt from *London*) then behind the Stile in the inner Circle write or engrave (*Mexico*) in the Middle (*London*) in the outermoſt (*Jeruſalem*); then having Recourſe to your Table, you find that *Mexico* is Weſt from *London* 6 Hours 49 Minutes, (or which is the ſame) when it is 12 a Clock or Noon at *Mexico*, it is 49 Minutes paſt 6 Afternoon at *London*; therefore lay a Scale from Q, the Center of the Dial, (which in this Caſe is not confined to the Center of the Circle) to 49 Minutes paſt 6 in the middle Circle for *London*, and there make a Stroke within the inner Circle, which ſhall be the Hour-line of 12 at *Mexico*: Likewiſe lay a Scale from the Center Q to 49 Minutes paſt 5 in the Circle for *London*, and there in the inner Circle for *Mexico*, place the Hour-line of 11, and ſo proceed round the Dial to lay the Scale to 49 Minutes paſt every Hour backwards from 6, you have the Hours from 12 to 11, 10, 9, 8, *&c.* at *Mexico*, and the ſame Shadow that gives the Hour at *London* in the middle Circle, gives at the ſame Time the true Hour at *Mexico* in the inner Circle.

EXAMPLE.

SUPPOSE I go to my Dial in the Forenoon, and find the Shadow of the Stile in the Line Q *k*, I find it is half an Hour paſt 9 at *London*, and in the inner Circle it is not quite three Quarters of an Hour paſt 2 in the Morning, *viz.* 41 Minutes paſt 2, and if you look at 6 in the Morning, it is at *Mexico* but 11 Minutes (*viz.* not a Quarter of an Hour) paſt 11 at Night.

By the ſame Rule you may inſert as many Places in your Dial as it will contain *Concentrick Circles*, and thereby give at one View the Hour at all the moſt remarkable or remote Places in the World.

The ſame Method is to be obſerved in any other Dial, whether Direct, Declining, Inclining, or Reclining, by placing the Hours at ſo much Difference, as is the Difference of Meridians between *London*, (or any other Place that the Dial is made for) and the Place aſſigned; but that the Learner may not be at a Loſs, I have likewiſe drawn a Specimen of a South Dial for *London*, *Jeruſalem* and *Mexico*, by which any Perſon may do the like for any other Places, and the Method ſo eaſy and intelligible, that it is not neceſſary to ſpend any more Time in Directions about it.

Plate 11. *Fig.* 2.

Note, You may by theſe Tables find the Hour at any Place aſſigned, without having it put upon a Dial, by ſubtracting the Difference of Meridians from the Time at *London*, if the Place be Weſt from *London*, or adding if it be Eaſt, and thereby having the Time of any Eclipſe, new or full Moon, &c. at *London*, may know at what Hour and Minute it is at any Place mentioned in the Table.

CHAP. X.

Inſtrumental DIALLING.

SECTION I.

Teaching how to draw the Hour-lines upon any Plain, by the Help of the Line of Hours, Inclination, &c.

THESE Lines may be inſcribed on the Side of any *Dialling Scale*, *Sector*, or any other Inſtrument of Braſs or Wood, and they are commonly known by the Name of the Line of Hours, Inclination, and Latitude, and if you have them upon any plain Scale, you ought to have Chords to ſeveral Radius's; but in this Caſe I would rather recommend a Sector, becauſe there you may take Chords, Sines, or Tangents to what Radius you pleaſe.

THE firſt of thoſe Lines is the Line of Hours, commonly known by the Word (Hours) at the Beginning of the Line; it contains 6 Hours, and is numbred with unequal Diviſions from I to VI.

THE next to that, and cloſe to it, is the Line of Inclination, known by this (*Incli.*) at the Beginning of it, and is 90 Degrees, divided in the ſame Proportion as the 6 Hours are, ſo that every 15 Degrees in one is an Hour in the other, to ſhew how many Hours and Minutes of Time anſwers to any given Number of Degrees and Minutes of the Equinoctial.

EXAMPLE.

I would know how many Degrees and Minutes of the Equinoctial is contained in an Hour and a half of Time. Look againſt an Hour and a half on the Line of Hours, and under that on the Line of Inclination you find 22 deg. 30 min. and ſo nuch is contained in an Hour and a half of Time.

THE next is the Line of Latitude, marked (Lat.) at the Beginning.

SOME have two Lines more, one marked (G Pol.) and the other (L Pol.) but by a Sector thoſe Lines may be more commodiouſly ſupplied from he Tangent; but I ſhall ſhew the Uſe of both, nd to avoid Prolixity, I ſhall fall directly upon Examples of the Uſe of theſe Lines in making Dials upon any Plain.

◆

SECTION II.

How to draw the Hour-lines on a Horizontal Dial, for Latitude 51 deg. 32 min.

FIRST, Draw the Line E W for the ſix a Clock Line, and at right Angles thereto draw the Line N S for the 12 a Clock Line to biſſect the former, where you intend to have the Center of your Dial as at A.

THEN fixing one Foot of your Compaſſes in the Beginning of your Line of Latitude, extend the other to 51 deg. 32 min. the Latitude of the Place, and ſet that Extent from A to E, and from A to W; then take in your Compaſſes the whole Scale of Hours, and with that Extent and one Foot in E or W, with the other Foot croſs the Meridian, or 12 a Clock Line in S, and draw the Lines E S and W S.

THEN take in your Compaſſes the Diſtance upon the Line of Hours from the Beginning of the Line to I, and ſet that Diſtance from S to 1 and 11, and alſo from E to 5, and from W to 7; take alſo the Diſtance from the Beginning of the Line to II on the Scale of Hours, and ſet from S to 2 and 10, and alſo from W to 8, and E to 4: Alſo the Diſtance from the Beginning of the Line to III, and ſet from S to 9 and 3, which will alſo be equal to the Diſtance W 9, or E 3. Now Lines drawn from the Center A through theſe Figures, 7, 8, 9, &c. to the Limb of the Dial (which may be ſquare or Round in what Form you pleaſe) gives the true Hour-lines of that Dial only for the Hours before 6 in the Morning, *viz.* 4 and 5, and likewiſe 7 and 8 at Night, they muſt be continued through the Center from their oppoſite Hours, and then are your Hour-lines finiſhed; and for the Stile, it muſt be a Plate of Braſs, or the like, to make an Angle of 51 32 (the Latitude of the Place) with the Plain, the Angular Point being fixed juſt at the Center A, and the Stile ſtanding upon the Meridian Line at right Angles with the Plain of the Dial, and then is your Dial finiſhed.

* * *

SECTION III.

How to draw Hour-lines upon a direct South Dial.

THE ſame Directions, that ſerve for a *Horizontal Dial*, may with a little Alteration ſerve for drawing the Hour-lines upon a South Dial, for if inſtead of taking the Latitude of the Place off from the Scale of Latitudes, you take the Complement, proceed in all Reſpects as before, only number the Hours the contrary Way, it will produce a South Dial. The Reaſon is, becauſe as the North Pole is elevated above the Plain of the Horizontal Dial, equal to the Latitude of the Place, ſo the South Pole is elevated above the Plain of the South Dial, equal to the Complement of the Latitude of the Place. Therefore if you would make a South Dial for Latitude 51 deg. 32 min. take 38 deg. 28 min. the Complement of the ſaid Latitude, (or if you work for any other Latitude, take always the Complement of the Latitude you work for) out of your Scale of Latitude, and work in all Reſpects as you did before, only accounting the Meridian-line for the Hour of 12, number the Figures the contrary Way, *viz.* to the right Hand of the Meridian, as Practice and even Reaſon itſelf will inform you; and as in the other the Stile made an Angle with the Plain of the Dial equal to the Latitude of the Place, ſo the Stile in this muſt make an Angle with the Plain of the Dial equal to the Complement of the Latitude, and both ſtand at right Angles with, or perpendicular to the Plain.

SECTION IV.

Of a Direct North Dial.

A North Dial is the ſame in all Reſpects with a South Dial, only in a North Dial the Stile points upwards towards the North Pole, becauſe the North Pole is elevated above the Plain of that Dial equal to the Complement of Latitude; for it is an univerſal Rule in all *Dials* that ſhew the Hour of the Day by a ſtrait lined Stile, to have that ſtrait Side of the Stile, whoſe Shadow gives the Hour, to lie parallel to the Axis of the World: and to point directly to that Pole which is elevated above the *Plain* of the *Dial:* And the Diviſions for the Hour-lines are the ſame, as in a South *Dial,* if they were to be inſerted; but as it would be ſuperfluous to deſcribe Hours which could never be ſhew'd by the Sun, it is proper to omit the Hours about Midnight, *viz.* 9, 10, 11, 12, 1, 2, 3, at which Hours the Sun is under the Horizon, even at the longeſt Day, in the Latitude of *London*; but if you work for a more Northerly Latitude, you muſt put on more Hours; as ſuppoſe you ſhould make a North *Dial* for Latitude 64 deg. 00 min. the longeſt Day there is 20 Hours 24 Minutes, its Complement to 24 Hours is 3 Hours 36 Minutes, the Length of the Night at that Time; half the Length of the Night is always the Time of the Sun's Riſing, which in the forementioned Latitude 64 deg. is 1 Hour 48 min. for the Time of Sun's Riſing in the Morning, and half of 20 Hours 24 min. *viz.* 10 Hours 12 min. is the Time of Sun's ſetting at the longeſt Day in that Latitude: But that the Artiſt need not be put to the Trouble of Calculation, I have inſerted a Table, which ſhews the Length of the longeſt Day in all Latitudes, either North or South, *viz.* from *Pole* to *Pole*; and although the ſame Table extended from the Equinoctial to the Polar Circles, might have ſerved in common Uſes, yet for the Satisfaction of the Curious, I have inſerted the whole as follows, A Table ſhewing the Length of the longeſt Artificial Days, in all Places from the Equinoctia to the Poles of the World.

Height of Pole	Longeſt Day H.	M.	Height of Pole	Longeſt Day H.	M.	Height of Pole	Longeſt Day D.	H.	M
0	12	0	47	15	42	68	42	1	1
6	12	20	48	15	52	69	54	16	2
12	12	42	49	16	0	70	64	13	4
16	12	58	50	16	10	71	74	0	
20	13	12	51	16	20	72	82	6	3
24	13	30	52	16	30	73	89	4	5
27	13	42	53	16	42	74	96	17	
30	13	56	54	16	54	75	104	1	
32	14	6	55	17	8	76	110	7	2
34	14	16	56	17	22	77	116	14	2
35	14	22	57	17	36	78	122	17	
36	14	28	58	17	52	79	127	9	5
37	14	34	59	18	10	80	134	4	5
38	14	38	60	18	30	81	139	31	3
39	14	44	61	18	54	82	145	6	4
40	14	52	62	19	20	83	152	2	
41	14	58	63	19	50	84	156	3	
42	15	4	64	20	24	85	161	5	2
43	15	12	65	21	10	86	166	11	2
44	15	18	66	22	18	87	171	21	4
45	15	26	66½	24	0	89	176	5	2
46	15	34	67	24Days		90	181	21	5
							187	6	3

The Uſe of this Table is very eaſy, for in th 4 firſt Columns you have the Length of the longeſt Day in any given Latitude in Hours and Minutes, and in the two laſt Columns you have th

Length of the longeſt Day in Days, Hours, and Minutes, the Sun in theſe Latitudes remaining above the *Horizon* during ſo many Days, while he is near his greateſt *Declination*, of the ſame *Denomination* with the Latitude of the Place, whether *South* or *North*, and when the Declination is contrary, the longeſt Night is the ſame Length.

EXAMPLE.

IN Latitude 60 deg. *North*, the *Longeſt Day* is 18 Hours 30 Minutes, which happens when the Sun enters *Cancer*, and hath 23 deg. 30 min. *North Declination*; but in 60 deg. *South*, the Day is the ſame length, when the Sun enters *Capricorn*, and ſo in the reſt, but beyond *Latitude 66* deg. 30 m. the Sun continues above the *Horizon* ſeveral Days, half of which is before the *Tropick*, and the other half after it.

EXAMPLE.

I deſire to know the *Longeſt Day* in *Latitude* 71 deg. 00 min. and I find it in the Table 74 Days, *viz.* 37 Days before the *Tropick*, and as many after it, which is from the 4th of *May* to the 17th of *July*, in all which Time the Sun never ſets in that *Latitude*.

BY this Table the Artiſts may know by Inſpection how many Hours are proper to be put upon any Erect, Direct, North Dial, or any *Horizontal Dial*, in any Latitude whatſoever.

SECTION V.

Of South or North Reclining Dials.

IN a Direct North or South Reclining Dial, there need be no Directions given, but what are already laid down, for all ſuch *Dials* are *South Dials*, or *Horizontal Dials*, in ſome other Latitude; for a *Horizontal Dial* in Latitude 51 32 or any other Latitude, is only a *South Dial* Reclining 90 deg. for in an Erect *South Dial*, the *South Pole* is elevated above the Plain of the Dial, equal to the Complement of the Latitude; therefore if a *North Dial* in *South Latitude*, or a *South Dial* in *North Latitude*, recline equal to the Complement of the Latitude, the Plain of the *Dial* becomes parallel to the Axis of the World, and Stile of the *Dial*, and then that becomes a *Horizontal Dial* under the Equinoctial, and hence theſe general Rules may be deduced.

1. IF a *South Dial* reclines leſs than the Complement of Latitude, it becomes a *Vertical Dial* for a Latitude, ſo much more than the given Latitude as the Reclination is. Or more plain, Add the Reclination to the Latitude, the Sum is the Latitude, where that is an Erect or Vertical Dial.

EXAMPLE.

SUPPOSE I would make a South Dial for Latitude 51. 32. North Reclining 22 deg. Add 22 d. to 51 deg. 32 min. the Sum is 73 deg. 32 min.

therefore make an erect direct *South Dial*, for Latitude 73 deg. 32 min. North, the ſame ſhall be a direct South *Dial* reclining 22 deg. for Latitude 51 32, and the Rules for making it are the ſame in all Reſpects.

2. If the Reclination be equal to the Complement of Latitude, it becomes a *Horizontal Dial* under the Equinoctial, for Reaſons before given. —— Therefore,

3. If a South *Dial* in North Latitude (or a North *Dial* in South Latitude) recline more than the Complement of Latitude, it will be a *Horizontal Dial* for ſuch a Latitude, as the Reclination is more than the Complement of Latitude: Or thus, ſubſtract the Complement of Latitude from the Reclination, the Remainder is a Latitude, for which if you make a *Horizontal Dial*, it ſhall alſo be the *Dial* for the Latitude and Reclination propoſed.

EXAMPLE.

I deſire to make a *Dial* for Latitude 60 deg. North, to recline 40 deg.

Subtract 30 the Complement of Latitude from 40 the Reclination, the Remainder is 10; therefore a *Horizontal Dial* for Latitude 10 North, is the ſame in all Reſpects as a South *Dial* reclining 40 deg. for Latitude 60 deg. North.

For it is plain, that if the Dial had reclined but 30 deg. the Plain had been parallel to the Axis of the World, but reclining 10 Degrees more, elevates the contrary Pole 10 Degrees, and becomes a *Horizontal Dial* for that Latitude.

Upon the ſame Ground we may deduce Rules for Incliners, for if we conſider, that the Stile of all Dials ſhould lie parallel to the Axis of the

World, and conſider how much the Angle, that the Stile makes with the Plain of the Dial, is augmented or diminiſhed by the Inclination of the Plain, it gives you the Latitude for which a *Vertical Dial* being made, it will be a North or South Dial with the given Inclination, and for the given Latitude, for which I think one Example ſufficient.

EXAMPLE.

I would make a South Dial for Latitude 51 32 North, to incline 10 deg.

It is evident, that this Dial that inclines 10 d. would be vertical, or perpendicular to the Horizon in a Latitude 10 Degrees leſs, therefore for a South Inclining Dial in North Latitude, or North in South Latitude.

1. If the Latitude be more than the Inclination, ſubtract the Inclination from the Latitude, the Remainder is the *Latitude* where the ſame *Dial* is Vertical.

2. If the Inclination be equal to the *Latitude*, it is an *Equinoctial Dial* under the *Equinoctial.*

3. If the Inclination be more than the Latitude, ſubtract the Latitude from the Inclination, the remainder is the Latitude, where the Dial is Vertical, but of a contrary Denomination, *viz.* if the *Dial* is to be made for North *Latitude* it is Vertical, in South *Latitude*, *& contra.*

For Direction about Eaſt and Weſt Recliners,
See Page 125.

SECT.

SECTION VI.

How to draw Hour-lines upon a direct Eaſt or Weſt Dial.

I Shall begin with an Example of an Eaſt Dial for Latitude 51, 32 North.

Plate 11. Fig. 2.

TAKE in your Compaſſes the Chord of 60, and with one Foot in C, draw the Arch A B, and ſet off the Complement of Latitude from A to B, and through B draw the Lines C, B, E, then ſomewhere towards the upper End of the Line C E as at R, draw G R F, perpendicular to C E for the Subſtile and Hour-line of 6, and draw H I parallel to E C, and at any competent Diſtance from it, then from one of the Lines marked (*Pol.*) on your Scale take the Diſtance from the Beginning of your Scale to I, and ſet that Extent from R to 5, and from R to 7; then take the Diſtance from the End of your Scale to II, and ſet from R to 4, and to 8, ſet alſo the Diſtance from the Beginning of the Scale to III, and ſet from R to 9, and ſo proceed to find the Hours of 10 and 11 by the Figures IIII, and V, upon the Scale and draw the Lines 4 4, 4 5, 7 7, *&c.* parallel to 6 6. Theſe ſhall be the Hour-lines required.

THE Diſtance from the Beginning of the Scale to III, is the Height of the Stile, and muſt ſtand upon the Hour-line of 6, and perpendicular to the Plain of the *Dial*, and then is your Dial finiſhed.

THE making of a Weſt Dial is all the ſame, only as the Eaſt *Dial* is elevated towards the left Hand equal to the Complement of Latitude, the Weſt *Dial* is elevated towards the right Hand, and inſtead of 4 5 6 7 8 9 10 11, in the Eaſt *Dial*, you muſt upon the Weſt Dial put on the Figures 1 2 3 4 5 6 7 8, becauſe the Afternoon Hours are deſcribed upon the Weſt Dial, as the Forenoon Hours are upon the Eaſt Dial.

BUT in working by thoſe Lines you are confined to a certain Bigneſs for your Dial (except you inlarge it afterwards) and therefore I hold it much better in this Caſe,to make uſe of the Tangents upon the Sector; and having firſt conſidered how large you intend your Dial ſhall be, and conſequently determined the Height of your Stile, take the Height of the Stile in your Compaſſes, and open the Sector, till the aforeſaid Extent will juſt reach from the Tangent of 45 on one ſide of the Sector, to the ſame Tangent on the other ſide, and keeping the Sector at that Opening, take in your Compaſſes the Tangent of 15 deg. and ſet from R to 5 and 7; take alſo the Tangent of 30, and ſet from R to 4 and 8; the Tangent of 45, or Radius, which is alſo the Height of the Stile, is the Hour-line of 9; and as every 15 deg. of the Equinoctial make an Hour of Time, ſo proceed to take the Tangent of 60 and 75, they give the Hour Marks for 10 and 11, from which drawing Lines croſs the Dial parallel to 6 6, as before directed, gives the Hour-lines required.

Plate 11. *Fig.* 2.

Note, When you would take a Tangent leſs than 45, you muſt make the 45 at the End of the Sector Radius; but when you would take a Tana Tangent above 45, you muſt make that 45 Radius, which is at the Beginning of the remaining Tangents, (which is alſo marked T) and proceed as before.

SECTION VII.

How to deſcribe Hour-lines upon direct East or Weſt Reclining Plains.

I Shall not trouble my ſelf to give any Directions for drawing Hour-lines upon Eaſt or Weſt Reclining Dials, conſidered as ſuch; for as in *Sect.* 5. you have Directions how to find in what *Latitude* any North or South Recliner becomes a *Vertical Dial* or an *Horizontal Dial*, and it is alſo ſhew'd in P. 125, how to reduce any Eaſt or Weſt reclining Plain to an erect declining Plain in another *Latitude*, or in what *Latitude* the given Plain ſhall be an erect Plain, and how much it declines; it will therefore be ſufficient to ſhew how to draw Hour-lines upon all erect declining Plains, becauſe in them all Eaſt and Weſt Recliners are included.

SECTION VIII.

To draw the Hour-line upon a North or South declining Plain.

I ſhall inſtance in a South Erect Plain declining Weſtward 24 deg. 20 min. for the Latitude of *London*, 51 deg. 32 min. North. (See Chap. 7. Page 46 and 47.)

HERE are two Things given, and 3 required before you can proceed.

Given	The Latitude	51	32
	The Declination	24	20

Required	The Subſtile's Diſtance from the Meridian.
	The Height of the Stile above the Plain.
	The Inclination of Meridians.

For the Subſtile's Diſtance from the Meridian.

As Radius	10.000000
To the Sine of the Plain's Declination 24 20.	9.614944
So Tang. Comp. of Latitude 38 28	9.900086
To Tang. of Subſtile's Diſtance from the Meridian 18 9	9.515030

2. *For the Height of the Pole (or Stile) above the* Plain.

As Radius	10.000000
To Sine Complement of Latitude 38 deg. 28 min.	9.793831
So Sine Complement of Declination 65 deg. 40 min.	9.959596
To Sine of the Stile's Height above the Plain 34 deg. 32 min.	9.753427

3. *For the Inclination of Meridians.*

As Radius	10.000000
To Co-Tangent of Declination 65 deg. 40 min.	10.344652
So is the Sine of Lat. 51 deg. 32 min.	9.893745
To the Co-Tang. of the Inclination of Meridians 30 d. 01 m.	10.238397

Or if you would confine your ſelf to Inſtrumental Operations, the ſame may be performed upon the *Gunter*'s Scale thus:

1. *For the Subſtile's Diſtance from the Meridian.*

The Extent from Radius to the Sine of the Plain's Declination 24. 20. will reach from the Tangent Complement of Latitude 38 deg. 28 m. to the Tangent of the Subſtile's Diſtance from the Meridian 18 9.

2. *For the Height of the Stile.*

EXTEND from Radius to the Sine Complement of Latitude 38 28, the ſame Extent will reach from the Sine Complement of Declination 65 40, to the Sine of the Stile's Height, 34 33.

3. *For the Inclination of the Meridian.*

THE Extent from Radius to the Sine of Latitude 51 32, will reach from the Co-Tangent of Declination 65 40, to the Co-Tangent of the Inclination of Meridians 30 00.

THE Requiſites thus found, draw the *Horizontal-line* H O, and in ſome convenient Part of that Line, as in C, fix the Center of your Dial, and from thence draw C 12 perpendicular to H O, then with 60 deg. of the Chord, and one Foot in C, make the Arch *y z*, upon which ſet off 18 deg. 9 min. the Subſtile's Diſtance from the Meridian from *y* to *x*, and draw C *x* F, for the Subſtile.

Plate 11. *Fig.* 3.

Note, The Subſtile muſt be on the right Hand of the Meridian, becauſe the Plain declines to the Weſtward, and ſhould have been on the left Hand, if it had declined Eaſtward.

THEN through C, and at right Angles with the Subſtile, draw the Line A B, and from the Scale of Latitudes take 34 deg. 33 min. (the Height of the Stile) and ſet from C to A, and from C to B. Take in your Compaſſes the whole Scale of 6 Hours, and with one Foot in A or B, turn the other about, till it touch the Subſtile, as in F, and draw the Lines A F and B F.

FIND the Inclination of Meridians (which in this Example is 30 deg.) in the Scale of Inclinations, and againſt that in the Line of Hours you find 2. Therefore take 2 Hours in your Scale, and ſet from F to 12, and from B to 6. Take alſo 1 Hour off the Scale of Hours, and ſet from F to 1, and from B to 7. In the ſame manner take 3 Hours off the Scale, and ſet from F to 11, and from B to 5. Likewiſe ſet 4 Hours off the Scale, from F to 10, and from B to 4. Alſo ſet 5 Hours off the Scale, from F to 9, and from B to 3, and for the 2 a Clock Line it happens to fall juſt in the *Subſtile*, becauſe the Inclination of the Meridian is juſt 30 deg. which at 15 deg. to an Hour, makes two Hours: And for the Hour of 8 in the Morning, continue the Hour-line of 8, which falls above the *Horizontal-line* on the right Hand, quite through the Center to the Edge of the Dial, and it ſhall be the Hour-line of 8 in the Morning, and for the reſt, draw Lines from the Center C through the Marks 1, 2, 3, 4, 5, *&c.* to the Edge of the Dial, they ſhall be true Hour-lines for that Dial.

THE *Stile* muſt ſtand upon the *Subſtile*, and perpendicular to the Plain of the Dial, the back Part of the Stile that gives the Hour by the *Shadow*, making an Angle of 34 deg. 33 min. with the Plain of the Dial equal to the Height of the *Stile* before found.

Note, The Inclination of the Meridian being juſt 30 deg. the *Subſtile* falls juſt upon the *Hour-line* of 2, but if it had been any other odd Number, as ſuppoſe 35 deg. this found in the Line of Inclination, there is againſt it in the Line of Hours, 2 Hours 20 Minutes, then you muſt have ſet off from the Line of Latitudes 2 Hours 20 Minutes, from F to 12, and from B to 6, and 0 Hours 20 min. from F to 2, and from B to 8, and ſo in any other Caſe.

In drawing this Dial, you have likewiſe made 3 more, for which to avoid Repetitions, I ſhall refer you to Page 50 in the 7th Chapter, and to the Figures of them in Plate 3. Fig. 4.

SECTION IX.

How to draw Hour-lines upon a Dial that declines ſo far, that the former Directions will not be ſufficient.

I Deſire to draw the Hour-lines upon an erect Plain, declining from the South Eaſtward, 80 deg. Lat. 51 32.

(See the ſame Chap. 8 Page 51.)

You are already taught in the laſt Section, how to find the Requiſites, which are by thoſe Rules found to be as followeth.

	deg.	min.
Subſtile's Diſtance from the Meridian.	38	2
Height of the Stile.	6	12
Inclination of Meridians.	82	9

Plate 11. *Fig.* 4.

Draw the Line H I, and with the Chord of 60, and one Foot in H, deſcribe the Arch M N, and from M ſet off the Subſtile and Stile to make their reſpective Angles with the Line H I, *viz.* the Subſtile to make an Angle of 38 deg. 2 min. and the Stile to make with the Subſtile an Angle of 6 deg. 12 min. or with the Line H I an Angle of 44 deg. 14. and draw H C B for the *Subſtile*, and H K L to repreſent the Stile.

THEN in any convenient Place towards the lower End of the Subſtile, as at B, draw a Line at right Angles with the Subſtile, as the Line F B D, then with one Foot of your Compaſſes at the Beginning of your longer Polar Scale, extend the other ~~to~~ the Hour of 3, ſet that Extent from B to D, and through D draw the Line D E parallel to the Stile H K L, then is D E the augmented *Stile*. Then with one Foot of your Compaſſes in the Beginning of your leſſer Polar *Scale*, extend the other to 3 Hours, and with that Extent place one Foot in the *Subſtile* B C H, carry it along the *Subſtile*, till the other Foot juſt touch the Line D E, which will be when the other Foot is in C, then make a Mark, and through C draw a Line parallel to the Line F B D, as the Line E C G; then find the Inclination 82 deg. 9 min. in the *Scale* of Inclination, and againſt it in the *Scale* of Hours you have 5 Hours 29 Minutes, which ſhews that the *Subſtile* falls between the Hours of 6 and 7 in the Morning (the Declination being Eaſterly) but had been between 5 and 6 in the Afternoon if it had been Weſterly.

Now if the Hour-line of 12 be 5 Hours 29 Minutes from the *Subſtile*, the Hour-line of 11 muſt be 4 Hours 29 Minutes from it, *&c.* and the Hour-line of 7 is 0 Hours 29 Minutes from it, and if ſo, the Hour-line of 6 muſt be 0 Hours, 31 Minutes on the contrary Side, becauſe 29 Minutes and 31 Minutes make juſt an Hour, *&c.* and all the other Diſtances, as in the following Table.

From B towards F.			From B towards D.		
H.	M.	Hour on the Plain.	H.	M.	Hour on the Plain.
0	29	B 7	0	31	B 6
1	29	B 8	1	31	B 5
2	29	B 9	2	31	B 4
3	29	B 10	3	31	B 3
4	29	B 11	4	31	B 2

THE Uſe of this Table is very eaſily underſtood for, take (according to the Table) 0 Hours 2 Minutes from the greater Polar *Scale*, and ſet from B towards F, it ſhall fall at the firſt ∗ in the Line I B F. Take likewiſe 1 Hour 29 Minutes, 2 Hours 29 Minutes, 3 Hours 29 Minutes, *&c.* from the ſaid greater Polar *Scale*, and ſet them upon the Line D B F, from B towards F, to the ſevera Points ∗ ∗ ∗ *&c.* and the contrary Way, ſe the Diſtances 0 Hours 31 Minutes; 1 Hour 3 Minutes, *&c.* upwards from B upon the ſame Line, to the Points ∗ ∗ ∗ *&c.* it finds the Points for the Hours of 6, 5, 4, *&c.* do the ſame by the leſſer Polar *Scale* from the ſame Table, and find the Marks ∗ ∗ ∗ in the Line E C G; then laying a Ruler over the two Marks next below the *Subſtile*, a Line ruled thereby ſhall be the Hour-line of 7, and by the two next Marks, a Line ruled ſhall be the Hour-line of 8; and ſo in all the reſt, as you ſee in the Figure.

The *Stile* in this, as in all others, muſt ſtand directly over the *Subſtile*, and muſt be a Plate of Iron or Braſs, and in the Form of the Figure B C E D.

In the making of this Dial, you have alſo made a *South Dial* declining Weſt 80 deg. only for the Hours 6, 7, 8, 9, 10, 11, you muſt put 1, 2, 3, 4, 5, 6, *&c.* You have alſo made a North Dial declining Eaſt 80 deg. and a North Dial declining Weſt 80 deg. with only inverting the *Stiles* and *Figures*, as you are taught Page 50, in the 7th Chapter before-mentioned, and the Figure (*Plate* 3. *Fig.* 4.) may ſufficiently illuſtrate this alſo.

SECTION X.

Of Declining Reclining Plains, and how the Hour-lines may be deſcribed on them.

Although we have elſewhere in this Book laid down ſeveral Methods for effecting this, yet in order to reduce the whole into as narrow a Compaſs as poſſible, we ſhall in this Section ſhew how thoſe Declining Reclining Plains may be reduced to new Latitudes, and new Declinations, and may be made by the Directions given in Sect. 8. by the Lines on the Scale.

EXAMPLE.

It is required to make a South Plain for Latitude 51 deg. 32 min. North, to decline from the South-weſtward 24 deg. 20 min. and to recline from the Zenith 54 deg.

The Canon to find the new Latitude is,

As Radius	10.000000
To Sine Compl. Declin. 24 20	9.959596
So Tang. Compl. of Reclin. 54 0	9.861261
To Tangent 33 30	9.820857

In South Reclining Plains, as our Example is, the Difference between the Tangent laſt found (which here is 33 30) and the Latitude of the Place is the Complement of the new Latitude ſought.

	deg.	min.
Latitude of the Place	51	32
Tangent found	33	30
Remains	18	2

whoſe Complement 71 58 is the new Latitude ſought. Only obſerve, that if the Tangent be more than the Latitude, the ſame Pole is elevated; if leſs, as here it is, the contrary Pole is elevated, and conſequently, if they be equal, neither Pole is elevated, but it is an Equinoctial Plain.

But for North Reclinesr,

If the Tangent laſt found be equal to the Complement of Latitude, the Plain is a Polar declining Plain; but if greater or leſſer than the Complement of Latitude, the Difference is the new Latitude.

The Canon to find the new Declination.

As Radius			10.000000
To Sine Compl. Reclin.	54	0	9.769219
So Sine of Declination	24	20	9 614944
To Sine of 14 deg. 1 min.			9.384163

This 14 deg. 1 min. is the new Declination, therefore if it be required to make a Dial for Latitude 51 deg. 32 min. to decline from the South-weſtward 24 deg. 20 min. and to recline from the Zenith 54 deg. 00 min. you may proceed (by the Directions given, Chap. 7. Page 46. of *Geometrical Dialling*, or Part 3. Sect. 3 and 8. in Pag. 129, and 141.) to make an upright Dial for Latitude 71 58 (the new Latitude) and to decline 14 deg. 1 min. from the South, (according to the new Declination found) that Dial ſhall ſerve for the Dial required.

Note, The Declination thus found, is always leſs than the old Declination was, but is always the ſame Way, *viz.* Eaſt or Weſt, as the old Declination was.

But to apply this new Dial to the Plain propoſed, you muſt not place the Meridian or Hour-line of 12 perpendicular to the Horizon, but it muſt make a certain Angle with the *Horizontal-line* of the Reclining Plain, which we call the Meridian Aſcenſion or Deſcenſion, which is found thus:

As Radius			1.000000
To Sine of Reclination	54	0	9.907958
So Tang. of old Declinat.	24	20	9.655348
To Tang. of 20 deg. 6 min.			9.563306

whoſe Complement 69 deg. 54 min. is the Angle that the Meridian makes with the Horizon.

Having thus obtained the Meridian, Aſcenſion or Deſcenſion, *viz.* the Angle that the Meridian makes with the Horizon, your next Work is to find the Poſition of the Meridian-line and Subſtile, for which ſee the three following Pages.

In North Incliners. South Recliners.	Leſs than Equinoctial the Meridian muſt be drawn.	above below	That End of the Horizontal Line, which lies contrary to the Coaſt of the Plain's Declination.
	More than Equinoctial, the Meridian muſt be drawn.	below above	That End of the Horizontal Line, which lies the ſame Way with the Coaſt of the Plain's Declination.
In North Recliners South Incliners.	Leſs than a Polar the Meridian muſt be drawn.	above below	That End of the Horizontal Line, that looks the ſame Way with the Coaſt of the Plain's Declination.—— And this Meridian thus drawn in North Recliners, repreſents 12 at Night.

In North Recliners. South Incliners.

- Equal to a Polar the Meridian muſt be drawn below the Horizontal Line at that End which is contrary to the Coaſt of Declination, and the ſix of Clock Hour-line is always the Subſtile.
- More than a Polar the Meridian muſt be drawn
  - below
  - above

  And from that end of the Horizontal Line, which lies contrary to the Coaſt of the Plains Declination.— And in South Incliners it is only ſerviceable to help to draw the reſt of the Dial.

1. To know which Way the Subſtilar Line of any Dial muſt ſtand from the Vertical Line of the ſame Plain. And,

2. How to order your Work in the Southern Hemiſphere.

For the Firſt.

Upon all Plains whereon the
North Pole — South Pole
is elevated, the Subſtilar muſt
lie from the
Upper End — Lower End
of the Vertical Line
toward the full
North — South

For the Second.

All the Rules, Precepts and Examples given in this Caſe, do ſuppoſe you to be in the Northern Hemiſphere of the World; therefore if you ſhould be in a Southern Hemiſphere, theſe Precepts will ſerve there alſo, by only changing the Words North and South one into the other, as for South read North, and for North read South, and ſo Northern for Southern, and the contrary.

For placing your Dial, draw an Horizontal Line upon your Plain, and ſet off ſo many Degrees by the Help of your Line of Chords, as the Diſtance of the Meridian and Horizon is found to be, and to the right Coaſt; there draw your Meridian-line, then apply your Paper Draught to your Plain, laying the Meridian-line of your Paper Draught exactly upon the Meridian-line (now found) upon your Plain, and take Care that the Subſtile lie according to the Directions now given, and that the Stile do always point towards the Pole, that is elevated above your Plain, and then by pricking through your Paper, or any other convenient Means, you may transfer the Hour-lines, *&c.* to your new Plain, and drawing the Hour-lines you have the Dial required.

As for Eaſt or Weſt Recliners or Incliners, the reducing them to erect Decliners in other Latitudes, and the Meridian-line in theſe Co-inciding with the Horizontal-line, and having no Elevation or Depreſſion, there is no Difficulty in placing them, when rightly made.

ALSO North and South Incliners or Recliners, being erect direct Dials in other Latitudes, are to be made as ſuch and then placed in the Latitude propoſed, with the given Reclination or Inclination, *&c.* which is eaſily intelligible to every Capacity.

SECTION XI.

How to make a Polar Dial.

IN making a Polar Plain, you have no more to do but draw a Circle, and divide it into 24 equal Parts for the Hours, and draw Lines from the Center of the Dial through theſe Diviſions to the Edge of the *Dial*, which may be round, ſquare or what Form you pleaſe, and placing 12 on that ſide towards the elevated Pole, put 11, 10, 9, *&c.* of the Forenoon Hours, and 1, 2, 3, *&c.* of the Afternoon Hours ſo far as you have Occaſion, will be the true Hour-lines of a *Polar Dial.*

Example of a Polar Dial for Latitude 51 d. 32 m.

Let the Square A B C D be your Plain, biſſect A B in *e*, and C D in *f*, and draw *e f*. Alſo biſſect B C in *g*, and A D in *h*, and draw *g h* perpendicular to *e f*; to cut each other in Q; then upon Q as a Cenetr, deſcribe the Circle *r ſ t u*, and beginning at *r*, divide the Quadrant *r ſ* into ſix equal Parts, and each of the Quadrants in the Points * * *, *&c.* Lines drawn from the Center Q thro' theſe Marks, are the true Hour-lines in ſuch a *Dial.*

Plate 11. *Fig.* 5.

Note, A *Polar Dial* to be placed under the *Pole*, ought to have all the 24 Hours upon it; but becauſe a *Polar Dial* to be placed in any other Latitude is only a North Dial reclining equal to the Latitude of the Place, and becauſe in Latitude 51 deg. 32 min. the Sun never riſeth till after 3 in the Morning and always ſetteth before 9 at Night, it will be ſufficient in this to inſert the Hours from 4 in the Morning to 8 in the Evening.

THE Stile is only a Pin of Braſs, Iron, or the like, fixed in the Center Q, and placed perpendicular to the Plain of the Dial.

SECTION XII.

Of an Equinoctial Dial. Pl. 11. Fig. 6.

AN Equinoctial Dial is a South Recliner in North Latitude, or a North Recliner in South Latitude, equal to the Complement of Latitude, and is moſt properly done upon an oblong Plain, thus;

AT a convenient Diſtance from the Edge of your Plain, draw the Line B C, and parallel thereto near the other Edge draw the Line D E, and through the Middle of theſe draw F G perpendicular to them, for the Hour-line of 12.

THEN upon either of the *Polar Scales* marked (*Pol.*) take the Diſtance from the Beginning of the Scale to I, and ſet that Extent from F, and alſo from G, both Ways to 11 and 1, on the Lines B C and D E. Again, Extend your Compaſſes from the Beginning of your *Scale* to II, and ſet that from F and G, both Ways upon the Lines B C and D E to 10 and 2; take alſo the Diſtance from the Beginning of the Scale to III, and ſet from F and G to 9 and 3, and in like manner take the Diſtance from the Beginning of the Scale to IIII, and ſet from F and G to 4 and 8. And laſtly, take the Diſtance from the Beginning of the Scale to V, and ſet from F and G to 7 and 5, (the Hour of 6 can never come into an Equinoctial Plain) then draw the Lines 7 7, 8 8, 9 9, &c. theſe are the true Hour-lines on that *Plain.*

THE Stile may be a thin Plate of Braſs, Iron, &c. and muſt ſtand upon the *Hour-line* of 12, perpendicular to the *Plain* of the Dial, its Top or Edge that caſts the Shadow muſt be parallel to the Hour-line of 12, and its Height muſt be the Diſtance between the *Hour-lines* of 12 and 3, and then is your Dial finiſhed.

OR, the ſame may be performed by the Help of a *Sector*, if you make the intended Height of your *Stile* Radius, and at that Opening ſet the Tangents of 15, 30, 45, 60, and 75 from the 12 a Clock Line both Ways to 11 and 1, to 10 and 2, to 9 and 3, to 8 and 4, and to 7 and 5, as you were taught in making an Eaſt Dial, to ſet the ſame from the 6 a Clock Line to the Hours of 7 and 5, 8 and 4, &c. which is ſo plain, that I need not enlarge upon it.

NOTE, *In this and all other Dials that ſhew the Hour by a Stile or Gnomon, you muſt allow for the Thickneſs of the Stile, imagining the Dial to be cut in two in the Subſtile, and the Parts drawn ſo far aſunder as the Thickneſs of the Stile*; for as it is impoſſible to make a *Stile* without ſome Subſtance in Thickneſs, it will follow that the Dial would be too ſlow, when the Weſt-ſide gives the Shadow, and too ſwift when the Eaſt-ſide gives it, if the *Subſtile* do not poſſeſs a Space equal to the Thickneſs of the Stile, to contain all the Shadow of the *Stile*, when the Sun is juſt perpendicular to it.

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Plate XI.

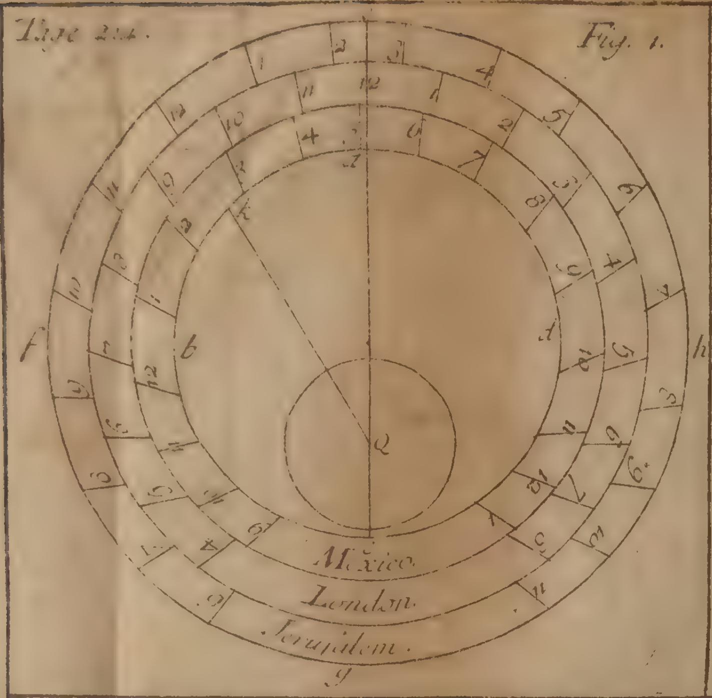
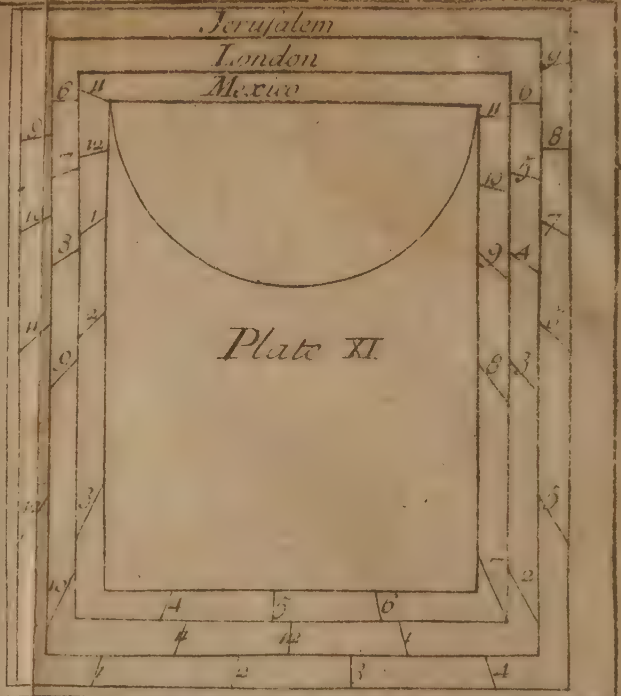
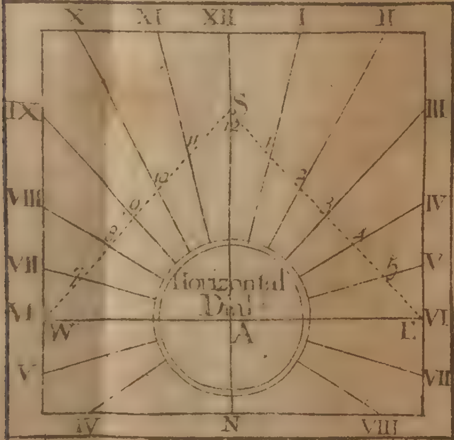


Fig. 1.





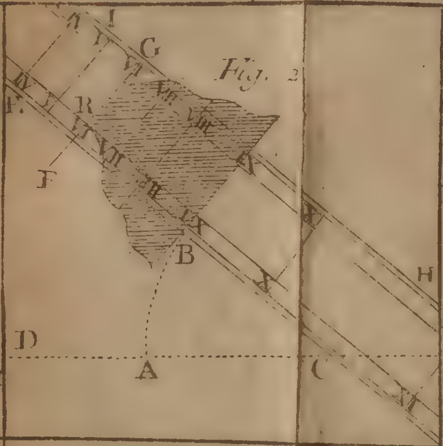


Fig. 2

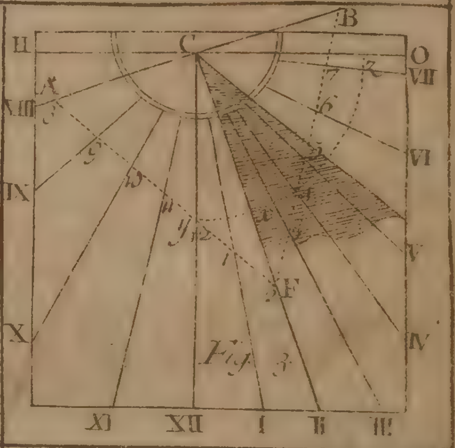


Fig. 3

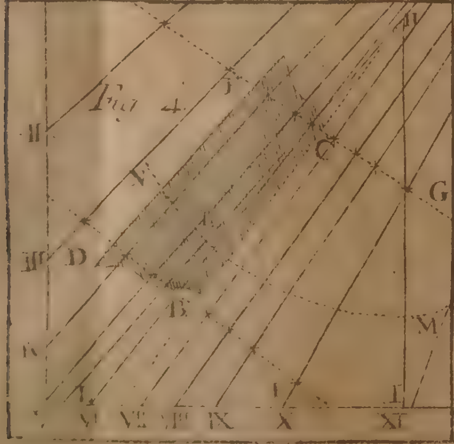


Fig. 4.

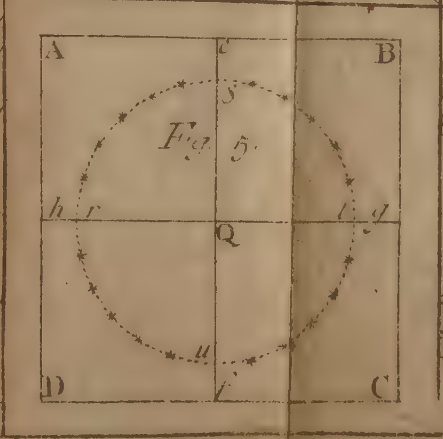


Fig. 5.

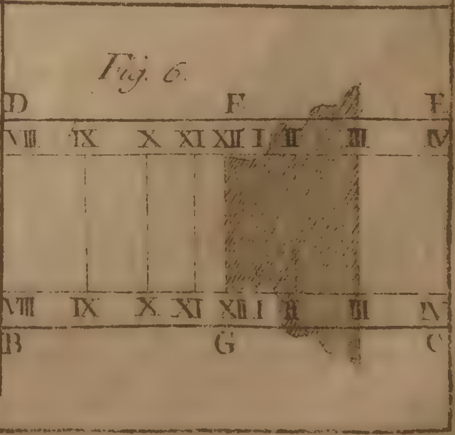


Fig. 6.

CHAP. XI.

Of Mechanick DIALLING.

Teaching how to make any Plain Dial either direct, declining, &c. without the Help of Mathematical Calculation, or any Inſtrument, except only a plain Ruler, and a Pair of Compaſſes.

ALTHOUGH the Varieties of Dialling before treated of (*viz. Geometrical*, *Arithmetical*, and *Inſtrumental*) might be thought ſufficient, yet becauſe this Book may come into the Hands of ſome that have not learned ſo much *Geometry* or *Trigonometry*, as to be capable to put thoſe Directions in Practice, or cannot procure a Ruler with the Dialling Scales upon it (which is the Caſe of many *Maſons*, *Carpenters*, &c. in the Country.) For the Sake of ſuch I have added this Chapter, whereby any Perſon that can but read and write, will be able to draw a Dial upon any Plain, provided he can raiſe or let fall a Perpendicular, and draw a Line parallel to a Line given, &c. which is taught at the Beginning of this Book.

SECTION I.

How to deſcribe the Hour-lines upon a Horizontal Dial.

I Shall, to avoid needleſs Repetitions, forbear to give any general Directions, and fall directly upon an Example. Let it therefore be required to draw a *Horizontal Dial* for Latitude 51 deg. 30 min.

First, Through the Middle of your Plain draw the Line A B for the Meridian, or 12 a Clock Line, and ſome where near the Middle of it, as at Q, croſs it at right Angles with the Line 6 6, then with any Extent of your Compaſſes, and one Foot in the Center Q, with the other deſcribe the Quadrant E B, which divide into 90 Parts thus; *Firſt*, With the ſame Extent of your Compaſſes, with which you ſwept the Quadrant, and one Foot in B, ſet the other towards E, and there make a Mark, for that is 60 deg. then with the ſame Extent and one Foot in E, ſet the other towards B, making alſo a Mark, thus is the Quadrant divided into three equal Parts, each containing 30 deg. Divide each of theſe Parts again into three equal Parts, then each of theſe laſt Diviſions into two equal Parts, each of which will be 5 deg. And laſtly, divide each of theſe laſt into 5 Parts, ſo will the Quadrant be divided into 90 equal Parts or Degrees.

Plate 12. *Fig.* 1.

Now becauſe the Latitude propoſed is 51½ degrees, count 51½ of thoſe 90 deg. from B towards E, which will reach to Z; then from the Center Q draw the Line Q Z for the Stile; aſſume a Point any where at Pleaſure, in the 12 a Clock-line, as at C, through which draw the Line L F parallel to the Line 6 6; this laſt Line we will for Diſtinction call the Tangent-line. Place one Foot of your Compaſſes in the Interſection of the Meridian and Tangent-line, as at C, and with the other take the neareſt Diſtance to the Stile Q Z, and keeping one Foot ſtill in C, turn the other about till it cut the Meridian-line in D; then upon D as a Center, with the ſame Extent D C, draw the Semicircle H C G, and draw the Diameter H D G parallel to L F, then with the ſame Extent, with which you draw the Semicircle, and one Foot in C, turn the other Foot both Ways towards H and G, and there make Marks, alſo with the ſame Extent, and one Foot in G, turn the other towards C, and where it falls upon the Semicircle make a Mark; then with the ſame Extent, and one Foot in H, turn the other towards C, and there alſo make a Mark, then is the Semicircle divided into 6 equal Parts; divide each of theſe Parts into two, and then it will be divided into 12 equal Parts; lay a Ruler from D, the Center of the Semicircle, over every one of theſe Diviſions, it will cut the Tangent-line in the Marks * * *, &c. And *Laſtly*, From the Center Q draw Lines through the Marks * * *, &c. in the Tangent-line, they ſhall be the true Hour-lines of the Dial.

If you deſire to have the half Hours and Quarters, you muſt divide each of the 12 Diviſions of your Semicircle into Halfs and Quarters, and transfer them to the Tangent-line, and from thence from the Center to the Dial, as you did the Hour-lines.

THE Lines being thus drawn, place 12 at the Middle or Meridian-line, and proceed towards the right Hand with 1, 2, 3, 4, 5, *&c.* and towards the left with 11, 10, 9, 8, *&c.* and for the Hours of 4 and 5 in the Morning, and 7 and 8 at Night, they are found by continuing the Hours of 4 and 5 in the Afternoon, and 7 and 8 in the Morning, quite through the Center, as you ſee in the Figure.

THE *Stile* is to be a thin Plate of Braſs, or the like, made in the Form of the Triangle B Q Z, to be erected perpendicularly upon the Line Q B, the Side Q B of the Stile, upon the Line Q B, and the Angular Point at Q, and then is your Dial finiſhed.

* * *

SECTION II.

How to deſcribe Hour-lines upon an Erect Direct South Dial. Plate 12. *Fig.* 2.

LET it be required to deſcribe a South Dial for Latitude 51 deg. 30 min.

Firſt, Through the middle of the *Plain* draw the Line A B, and at the upper End thereof, as at A, croſs it at right Angles, with the Line 6 A for 6 a Clock, or an Eaſt and Weſt Line; then with as large an Extent of your Compaſſes as your Plain will admit of, and one Foot in A, deſcribe the Quadrant B C, which divide into 90 Parts or Degrees, as you were taught Sect. 1. of which ſet

38, 30

38, 30 the Complement of the Latitude from B to E, and draw A E for the Stile, then aſſume a Point at Pleaſure in the Line A B, as at F, thro' which draw the Line O F H, perpendicular to A B for a Tangent-line; with one Foot of your Compaſſes in F, with the other take the neareſt Diſtance to the Stile A E, and keeping that Foot ſtill in F, turn the other till it cut the Meridian-line A B in G, then letting that Foot reſt in G, with the other deſcribe the Semicircle I F L, which divide into 12 equal Parts, as you were taught to divide the like Semicircle in *Sect.* 1. of this Chapter. Lay a Ruler from G, over the equal Diviſions in the Semicircle, and it will cut the Tangent-line O F H in the Marks * * *, *&c.* *Laſtly*, Draw Lines from the Center A through the Marks * * *, *&c.* in the Tangent-line, they ſhall be the true Hour-lines of the Dial.

HAVING thus finiſhed the Hour-lines, place 12 at the End of the Line A B, and (ſuppoſing the *Dial* to face the *South*, and your Face towards it) proceed with 1, 2, 3, *&c.* towards the right Hand, and with 11, 10, 9, *&c.* towards the left Hand, always obſerving that a *South* Dial can never contain any more Hours than thoſe from 6 in the Morning, to 6 in the Evening.

THE *Stile* may be a Plate of Braſs, or the like, in Form of the Triangle, B A E, the ſide B A to be ſet upon the Line B A perpendicular to the Plain of the Dial, the Angle of the Stile being juſt at the Center or Point A of the Dial, and then is your Dial finiſhed.

SECTION III.

Of an Erect Direct North Dial.

THE *Erect Direct North Dial* is made by the ſame Rules as a *South Dial* is made, the Hour-lines and Stile being the ſame, only in a North Dial the Stile points upwards, making alſo an Angle with the Plain of the Dial, equal to the Complement of Latitude; and for the reſt obſerve.

1. To put no more Hours than are of Uſe, as at *London*, 4, 5, 6, 7, 8; in the Morning, and 4, 5, 6, 7, 8, in the Evening, the Sun never ſhining on a North Plain at any other Hours.

2. That (though the Diviſions are the ſame) the Hours, which on the *South Dial* are marked 6, 7, 8, in the Morning, muſt on the *North Dial* be marked 4, 5, 6, in the Morning; and the Hours of 4, 5, 6, in the Afternoon, muſt be 6, 7, 8, in the Evening.

3. Because upon a *South Dial* you never draw any Hour before 6 in the Morning, or after 6 in the Evening; but the North Dial (at *London*) takes in 4 and 5 in the Morning, and 7 and 8 in the Evening: Therefore to ſupply that on the North Dial, you need but continue the Hour-lines of 4 and 5 in the Afternoon quite through the Center, and that gives you the Hour-lines of 4 and 5 in the Morning on the oppoſite Side, and the Hour-lines of 7 and 8 alſo continued, gives you the Hours of 7 and 8 in the Evening.

4. As for what Hours are neceſſary to be put upon a *North Dial* in any other Latitude, I ſhall refer you to the Table (*Page* 190.) with its Explanation immediately following; there you have the Length of the *Longeſt Day* in all Latitudes, whereby you may find the Sun's Riſing and Setting in all Latitudes, and conſequently know what Hours in the Morning or Evening are proper to be put upon a *North Dial*, it being ſuperfluous to put on the Hours before Sun-riſe, or after Sun ſet.

5. If a North Dial for any given Latitude be required to be made, take a Sheet of oyl'd Paper, and proceed in all Reſpects by the foregoing Directions to make a South Dial for the Latitude propoſed, (only you may ſave the Labour of working for the Hours that you know will be of no uſe) which done, turn the Paper over, taking that End towards you which was fartheſt from you, and you will ſee through the Paper the true North Dial required, which I think will not need any further Explanation.

SECTION IV.

How to deſcribe an Erect Direct Eaſt Dial. *Plate* 12. *Fig.* 3.

Having prepared your Plain W X Y Z, whether Wood, Braſs, *&c.* Draw towards one Side of it the Line A B parallel to W Z, and in that Line chuſe a convenient Point towards the upper End thereof, as C, upon which as a Center, with any Extent of your Compaſſes deſcribe the

Arch D E, upon which from E, ſet off the Complement of Latitude, which in this Example we will ſuppoſe to be Latitude 54 deg. whoſe Complement to 90 is 36, ſet off therefore 36 deg. from E to D, and draw D C for the *Axis* of the World, then croſs this Line at right Angles with the Line C F, drawing C F both Ways to the Edges of the Plain; chuſe any convenient Point in the Line C F, as at 6, from which draw the Line 6 6 parallel to C D for the Subſtile and Hour-line of 6, (which in *Eaſt* or *Weſt Dials* are always the ſame) continue the Line 6 6 at Pleaſure, as to G, with the Extent from G to the Line C F, keeping one Foot of the Compaſſes in G, with the other deſcribe the Semicircle Q R, which divide into 6 equal Parts both Ways from the Line G 6, and laying a Ruler from G over theſe Diviſions, it will cut the Tangent-line C F in the Points * * *, &c. from every one of which Marks draw Lines parallel to C D, they ſhall be the Hour-lines required, which (beginning at 6) muſt be numbred upwards with 5 4, and downwards with 7, 8, 9, 10, 11, the Hour of 12 can never come into an Eaſt Plain, becauſe at that Hour the Sun being upon the Meridian, is juſt upon the Edge of the *Plain*.

The Stile is a thin Plate to be fixed upon the Hour-line of 6 perpendicular to the *Plain* of the Dial, being from End to End, equally of the Height of the Line G 6, the Extent with which you drew the Semicircle.

SECTION V.

Of an erect direct Weſt Dial.

AN erect direct Weſt *Dial* is deſcribed in all reſpects by the Rules given for the *Eaſt Dial*, only appear differently in two Particulars.

1. THE *Eaſt Dial* is elevated towards the Left Hand, but the *Weſt Dial* is elevated towards the Right Hand, as the *Eaſt Dial* would appear, if ſeen through the Paper, the Diviſions being alſo exactly the ſame.

2. WHEREAS the *Eaſt Dial* contains the Forenoon Hours, and is numbred from the upper Part downwards, with 4, 5, 6, 7, 8, 9, 10, 11, the *Weſt Dial* contains the Afternoon Hours, and is numbred from the lower End upwards, with 1, 2, 3, 4, 5, 6, 7, 8, the Stile being the ſame, and ſtanding upon the Hour line of 6 in both.

For the Figure of a Weſt Dial, ſee Plate 3. *Fig.* 2.

SECTION VI.

How to deſcribe the Hour-lines, &c. *upon an Erect South (or North Dial) declining Eaſt.*

ALTHOUGH we have given Directions (Chap. 2. Page 34.) for finding the Declination of any Plain, yet theſe Directions requiring ſome Knowledge in Aſtronomy previous to the Practice of them, and this being deſigned for the Uſe of thoſe that have not acquired a ſufficient Knowledge in the Mathematicks, I ſhall give a Method, whereby (mechanically) to take the Declination of any Plain, as followeth,

TAKE a fine Board of Wainſcot, or the like, of about a Foot ſquare, or more or leſs at Pleaſure, and plain it very Fine, or elſe paſte a Sheet of ſtrong white Paper very ſmooth, on one Side of it, as you ſee in the Figure, the Board repreſented by A B C D. From the middle of the Side A B, erect the Perpendicular x y z, and in the middle thereof, as at *y*, place one Foot of your Compaſſes, and with the other point at ſeveral different Extents, draw the *Concentrick Circles*, as you ſee in the Figure, (it matters not what Diſtance they are from each other, or whether they be equally diſtant among themſelves) this done, erect a ſmall Pin of 3 or 4 Inches in Length, exactly perpendicular in the Center of the Circles, and then is your Inſtrument ready for uſe.

Plate 12.
Fig. 4.

Note, If you are doubtful of your Performance in erecting the Pin exactly perpendicular, you may place the Pin before you make the Circles, and then with one Foot of your Compaſſes in the middle of the Top of the Pin, with the other deſcribe the Circles as before, and then you are ſure that the Middle of the Top of the Pin, where you placed your Compaſſes, is perpendicular to the (ſuppoſed) Center of the *Circles*, whether the Pin be perpendicular to the Plain, or no, and then draw a Line perpendicular to the Side A B, and to cut each *Circle* exactly in two Parts, proceed to make uſe of the Inſtrument, as followeth.

PLACE the Inſtrument exactly parallel to the Horizon, with the ſide A B againſt the Wall or Plain, whoſe Declination you deſire to know, and then about 7, 8 or 9, in the Morning, (when the Sun is clear of the Refraction of the Horizon, and before 10 or 11 a Clock, becauſe then the Sun riſes but ſlowly) obſerve which of the *Concentrick Circles* the Top of the Shadow of the Pin cuts, and where it cuts it, and there make a Mark. This done, let your Inſtrument ſtand un-removed till the Afternoon, and then wait till the Top of the Shadow cuts the ſame *Circle* again (for all the Time between the Obſervations the Top of the Shadow will cut the inner Circles) and there where it cuts the ſame *Circle* make a Mark, then divide the Space between theſe two Marks into two equal Parts, and in the exact Middle between them, on the ſame *Circle*, make another Mark, for that ſhall be the true North Point; then (as you were taught in *Sect.* 1. of this *Chapter*, or by the help of a Line of *Chords* on a Sector, if you have it) find how many Degrees are contained between the laſt Mark found, and the Point where the Line x y z cuts the ſame *Circle*, for that is the Declination of the *Dial*; and if the Mark laſt found falls on the Eaſt-ſide of the Line x y z, the Dial declines Eaſt, if on the Weſt-ſide, it declines Weſt, but if the Line be juſt in the Middle between the two Marks, it is a true South Plain, and hath no Declination at all.

Note, In your Morning and Afternoon Obſervation, as above, you need not regard the Hour of the Day, nor the Sun's Altitude, ſo as to know what they are, but only obſerve the two Points, where the Top of the Shadow cuts the ſame Circle as before, and if at your firſt beginning in the Morning, the Top of the Shadow doth not fall exactly upon a *Circle*, wait till it doth; for a the Sun riſes the Shadow paſſeth from one *Circ* to another, *viz.* from the greater to the leſſer, an the contrary at his falling in the Afternoon.

Having thus found the Declination of th *Plain*, your next Work is to proceed to make th Dial, which for an Example, ſhall be a South Dial, declining Eaſt 40 deg. for Latitude 54 deg. 00 min.

Plate 12. *Fig.* 5.

In performing the Work of this one Dial, you have alſo made three more, as is farther demonſtrated Page 50 and 51, and *Plate* 3. *Fig.* 4. to which I ſhall refer the Learner for farther Inſtruction in that Variety: But of theſe four the South declining Eaſt is that in the lower Part of the Projection, for making of which, firſt, towards the upper part of your Plain, draw the Line E W for the Eaſt and Weſt, or Horizontal-line, in which chuſe a Point, as at A, for the *Center* of your Dial, upon which deſcribe the Semicircle Z M E. Through the Point A, in the Horizontal-line E A W, and at Right Angles to it draw the Line A M, which divides the Semicircle Z M E into two Quadrants, of which that towards the left Hand, *viz.* the Quadrant A Z M, ſerves for our preſent Purpoſe, becauſe the Dial declines Eaſt, and conſequently the Subſtile, &c. falls in that Quadrant: Therefore, ſet 40 deg. (the Plain's Declination) from M towards Z, upon the Arch M Z, and through the Point where that falls, and from the Center A, draw A D the Line of Declination, then ſet the Complement of Latitude, *viz.* 36 (becauſe the Latitude is 54, and its Complement to 90 is 36) from M the ſame Way upon the ſame Arch, and thro' the Mark where that falls, and from the Center A, draw the polar Line A P, then aſſume a Point at pleaſure in the *Horizontal-line* W A E, at a convenient Diſtance from A, as at B, and from thence draw a Line parallel to A M, to cut the polar Line A P in P. From P draw a Line parallel to the *Horizontal-line* W A E, as the Line P C. Take the Diſtance A B upon the *Horizontal-line*, and ſet on the Line A D from A to D, and through D draw a Line parallel to A M, to come into the *Horizontal-line* at R, and continue it through D till it cut the Line P C in S, a Ruler laid from A to S, and the Line A S drawn thereby, is the *Subſtile* of the Dial. Then at the Point S erect a Perpendicular to the Line A S, as the Line S T. Set the Diſtance R D from S to T, and draw the Line A T, ſo ſhall the Triangle S A T repreſent the Stile of the Dial; for a Triangular Plate in that Form, erected perpendicularly upon the *Subſtile* A S, ſhall by its upper ſide A T caſt a Shadow to the Hour of the Day, when the Hour-lines are drawn, which is the next Thing to be done.

For drawing the Hour-lines, aſſume a Point in the *Subſtile* at pleaſure, through which, and at Right Angles with the *Subſtile*, draw the Tangent-line F F as long as you can, and ſetting one Foot of your Compaſſes, where the Tangent-line cuts the *Subſtilar*, take with the other the neareſt Diſtance to the *Stile*, or Line A T, and with the ſame Extent, one Foot remaining in the Point of Interſection, with the other find the Point Æ in in the *Subſtile*, and with the ſame Extent (one Foot reſting in Æ) deſcribe the Semicircle m n; this done, lay a Ruler from Æ, (the *Center* of the *Semicircle*) to the Point where the Tangent-line E F cuts the Meridian A M, as at O; begin at O to divide the Semicircle into 12 equal parts, at every one of which make a Mark Then lay a *Scale* from Æ, the Center of the *Semicircle*, over the ſaid Marks, it will cut th Tangent-line in the Marks * * * *, &c. And laſtly, lay a *Scale* from A, the Center of the Dia over theſe Marks * * *, &c. in the Tangent-line and Lines drawn thereby will be the true Hour-lines of that Dial.

In this, as in a South Dial, the Hour of 1 is at the Meridian, or middle Line of the Dia and the reſt numbred forwards with 1 2, and backwards towards the left Hand with 11, 10, 9, 8, 7 6, 5, 4, as you ſee in the Figure.

SECTION VII.

Of Dials declining from the South Weſtward. Plat 12. *Fig.* 5.

FIRST, Draw the *Horizontal-line* W A E, an upon the Point A in the middle of it, as a *Center*, deſcribe the Semicircle Z M E, as you ſe taught in the laſt Section for Dials declining fro the South Eaſtward, and draw A M perpendicula to W E, which will divide the Semicircle Z M E into two Quadrants; and as in the South Eaſ declining Dial, the Quadrant A Z M was of uſe ſo in this the Quadrant A E M muſt be made uſ of, becauſe in it the *Subſtile* and other Parts of th Work neceſſarily fall, and there is no Differenc in the Operation, only inſtead of ſetting from A or M, &c. to the left Hand in the laſt, you ſe from A or M, &c. to the right Hand in this; ſo that if the laſt had been drawn upon oyl'd Paper, or any other tranſparent Thing, ſo as to be ſeen through on the back ſide of the Paper, it would be exactly a South Dial declining Weſt, as far as the other did Eaſt, and for the ſame Latitude only, the 11 muſt be 1, and the 10 muſt be 2, and ſo in the reſt, and the North Decliners are alſo deduced therefrom, as is taught at large Page 50 and 51, before-mentioned.

* * *

SECTION VIII.

Of Eaſt or Weſt Reclining or Inclining Dials.

ALTHOUGH we have given Directions (Page 125,) for reducing Eaſt and Weſt Recliners for any given Latitude to new Latitudes and new Declinations, and ſo may be performed by the Directions given in Sect. 6 and 7. of Mechanick Dialling, yet I ſhall here, for the Learner's Improvement, ſhew how they may be done *Mechanically*, without any ſuch Alteration, whether they be Eaſt or Weſt, Reclining or Inclining.

IT will be neceſſary firſt to premiſe, that Eaſt and Weſt Recliners have their Centers near the Bottom, and in this the Incliners of both Sorts have their Centers near the Top: The Weſt Recliner and Eaſt Incliner ſhould have their Centers toward the right Hand, and the Weſt Incliners and Eaſt Recliners have their Centers moſt commodiouſly towards the left Hand: Therefore,

SUPPOSE I would make an Eaſt Dial to recline 45 deg. for Latitude 54 deg.

HAVING prepared my ſquare Plain W X Y Z, I conſider by the foregoing Rules where I may moſt conveniently chuſe my Center; and I find firſt, that all Recliners both Eaſt and Weſt, have their Centers at or near the Bottom; and ſecondly, I find that Eaſt Recliners ſhould have their Centers moſt towards the left Hand; therefore at the Bottom of the Square W X Y Z, draw the Line S N for the Meridian, in which, not at the Middle, but rather towards the left Hand, as at A, I chuſe the Center, and from A perpendicular to the Line S N, draw A E; alſo with one Foot of your Compaſſes in A, deſcribe the Quadrant T U, and ſet off 45 Degrees (the Reclination of the Plain) from T towards U, and through that Point in the Quadrant where the 45 Degrees end, and from the Center A draw the Line A O. Alſo ſet off upon the ſame Quadrant from T, the Complement of Latitude 36 Degrees, and thro' the Point where that reaches upon the Quadrant, and from the Center A draw the Line A P; then in the Meridian Line N S chuſe a point at pleaſure, as B, and from that Point draw a Line parallel to A E, which will cut the Line A P in P. From that Interſection at P, draw a Line parallel to the Meridian-line S N, to come to the Perpendicular A E in C; and alſo from the Line A O in O, take the Diſtance A O, and ſet upon the Perpendicular A E, from A to E, and draw E G parallel to S N, which will cut B P continued in G; ſet alſo the Diſtance C O from A to Q, upon the Line A O, and draw the Line Q R parallel to B P; take alſo in your Compaſſes the Diſtance A R (from the Line S N) and ſet it off upon the Line G B, from G to S, a Line drawn from A to S ſhall be the *Subſtile* of the *Dial*. Draw S M per-

Plate 12. *Fig.* 6.

perpendicular to A S, and take in your Compaſſes the Diſtance Q R, and ſet from S to M, and laying a Ruler from the Center A to M, a Line drawn by it ſhall be the ſtilar Line, the Triangle A S M repreſenting the *Stile*, which being erected perpendicular to the Plain of the Dial upon the *Subſtile* A S, ſhall give the Hour by the Shadow of its upper Edge, which will be parallel to the Axis of the World.

For drawing the Hour-lines, chuſe a Point at pleaſure in the Subſtile A S, and through that at right Angles draw the Tangent-line I K as long as you can, and with one Foot of your Compaſſes in the Point where the Tangent-line I K croſſes the *Subſtile* A S, take with the other the neareſt Diſtance to the *Stile* A M, which done, (keeping the other Foot yet in the aforeſaid Interſection) turn the Compaſſes about, till it cuts the Stile A S, as in Æ, and fixing that Point in Æ, with the other at the ſame Extent deſcribe the *Semicircle* l n; draw a Line from Æ the Center of the *Semicircle*, to the point where the Tangent-line I K, cuts the Perpendicular, and obſerve where it cuts the Semicircle, and there begin to divide it into 12 equal parts. A Ruler laid from Æ over the equal Diviſions of the *Semicircle*, will cut the Tangent-line I K unequally in the points * * *, *&c.* And *Laſtly*, a Ruler laid from the Center A to theſe Marks * * *, *&c.* in the Tangent-line, and Lines drawn thereby, ſhall be the true Hour-lines required.

The Line S N being the Meridian and Hour-line of 12, you muſt place 12 at the End of it, and the reſt 11, 10, 9, 8, 7, 6, 5, 4, as you ſee in the Figure

In drawing this, you have in Effect drawn three more; as,

1. If it was turned upſide down, the ſam ſide is a Weſt Dial inclining 45 deg. only t Hours are for the Afternoon, as for 11 put 1, f 10 2, and then the *Subſtile* will conſequently b as much on the right Hand of the Perpendicu lar, as now it is on the left.

2. If it was drawn on oyl'd Paper, the bac ſide would be a Weſt Dial reclining 45 deg. on the Figures inſtead of 12, 11, 10, 9, &c. muſt b 12, 1, 2, 3, &c.

3. If the Meridian-line S N be turned upward the Back-ſide will be an Eaſt Dial inclining 45 and the Figures, as they are, only the Subſti muſt be as far to the left Hand of the Perpendicu lar A E, as now it is on the Right.

SECTION IX.

Of Direct South or North Plains Inclining or Reclining.

IT is needleſs to give any Directions about direct North or South Reclining or Inclinin Dials, becauſe they are erect direct North or Sout Dials in ſome other Latitude; and how to reduc them to ſuch, you are fully taught in Sect. 5. o *Inſtrumental Dialling*, Page 192, 193, 194, an when they are reduced to direct North Dials in an other Latitude, they are made by the Direction given, page 218, and 220, to which (to avoid Repetitions) I ſhall refer the Learner in this Caſe.

SECTION X.

To deſcribe the Hour-lines upon a South or North Inclining, Declining, or Reclining Plain.

THESE Dials, though different in Situation, are the ſame as to the Method of Projection; for the South Inclining Declining, and North Inclining Declining, as alſo the South Reclining Declining, and likewiſe the North Reclining Declining, are the ſame, only differently placed, and are to be projected by the following Rules.

NOTE, You are taught in *Sect.* 10. of *Inſtrumental Dialling*, *Pag.* 205. how to reduce (*Plate* 12. *Fig.* 7.) any Declining Reclining *Dial*, for any given Latitude, to a new Latitude and new Declination, where it will be an upright declining *Plain*; which being done, you may proceed according to the Directions given in *Sect. 6.* of *Mechanick Dialling Pag.* 223 to 228; but becauſe that requires *Trigonometrical Calculation* for finding the new Latitude and new Declination, (which we ſuppoſe ſome *Mechanicks* are not capable of) I ſhall ſhew how it may be done without any *Trigonometrical Operation* whatſoever.

I ſhall inſtance in a *South Dial* declining Eaſt 26 deg. and inclining 36 deg. for Latitude 51 d. 30 min.

DRAW a Line on the upper-ſide of your *Plain* parallel to the *Horizon*, which mark with E W *viz.* (becauſe the *Dial* faceth to the *Southward*) put E at the right Hand for Eaſt, and W at the left Hand for Weſt; aſſume a Point in the Lin E W, as at A, for a Center, upon which, wit any Extent of your Compaſſes, (the longer th better) draw the Quadrant x y, and through x draw the Line A x X perpendicular to W E; divide th Quadrant into 90 Degrees, as you are taught i *Sect.* 1. of this Chapter, *Page* 216. or by a Lin of Chords (the making of which I ſhall ſhew hereafter) which is much more expeditious, and upo theſe Degrees of the Quadrant, ſet from x th Complement of Latitude 38 ½ deg. the Declination 26 deg. and the Inclination 36 deg. makin Marks in the Quadrant where theſe Degrees ſhal fall, and through theſe Points in the Quadrant, and from the Center A, draw the Lines A b, A e, and A d. Then chuſe a Point in the Line E W, towards the Quadrant, as at B, from which draw a ſtrait Line perpendicular to E W, or parallel to A X, as the Line B P, to cut the Line A d (the Line drawn from the Center A through the point where the Complement of Latitude reaches in the Quadrant) in the point P, and thro' that Interſection at P draw the Line P C paralle to W E, which will cut the Line of Inclination A e in O. Take in your Compaſſes the Extent A O, and ſet on the Line A x from A to F, and through F draw F G parallel to P C; then take in your Compaſſes the Extent C O, and ſet it on the Line A X, from A to L, and draw L D parallel to W E, to cut the Line of Declination A b in D. Set the Diſtance A B from A to V, upon the Line of Declination A b, and from V draw V K parallel to W E, to cut the Line A X in K. Take in your Compaſſes the Extent V K, and ſet off upon the Line G F, (but on the contrary Side of the Perpendicular) from F to M, and draw M N parallel to A X, to cut the Line W E in the point N. Then

N. Then becauſe the Plain is a South *Incliner*, (or if it had been a North *Recliner* it had been the ſame) take in your Compaſſes the Diſtance L D, and ſet upon the Line F G, from F to H, for a Meridian-line, or the Hour-line of 12; take in your Compaſſes the Diſtance A L, and placing one Foot in K, extend the other to the Point X; then take the whole Diſtance A X, and ſet upon the Line of *Inclination* A e, from A to Q, and from Q draw Q R parallel to B G, to cut the Horizontal line W E in R; take in your Compaſſes the Extent A R, and with one Foot in M, extend the other in the Line M N to the Point S, and draw the Line A S for the Subſtile, and draw S T perpendicular to A S, and upon the Line S M ſet the Diſtance Q R from S to T, and draw the Line A T for the Stile, ſo ſhall the Triangle A S T repreſent the Stile to be erected perpendicular to the Line A S, and to ſtand upon that Line, the Side A T being parallel to the Axis of the World, and its Shadow upon the Hour-lines determining the Hour of the Day.

For drawing the Hour-lines upon this Dial, chuſe a Point in the Subſtile A S, and through that Point, and perpendicular to A S, draw the Tangent-line E g to cut the Subſtile A S in the Point h, take the neareſt Diſtance from the Point of Interſection at h to the Stile A T, and keeping one Foot in h, turn the other about to the Point Æ, in the Subſtile A S; then keeping that Foot in Æ, with the other draw the Equinoctial Circle to touch the Tangent-line; then lay a Ruler from Æ the Center of the Equinoctial-line, to the Point where the Tangent-line cuts the Meridian-line A H, as in the Point ⊙, and obſerve where that Ruler cuts the Equinoctial Circle, and from that Point begin to divide the Semicircle into 12 equal Parts, as you were taught, *Page* 217. and then, as you have been formerly taught, lay a Ruler from the Center of the Equinoctial at Æ over the equal Diviſions in the Circle, and obſerve, where it cuts the Tangent-line, as in the Points ✱ ✱ ✱, *&c.* And laſtly, Lines drawn from the Center A thro' the Marks ✱ ✱ ✱, *&c.* ſhall be the true Hour-lines of that Dial.

FOR numbring the Hours, place 12 at the Meridian-line at H, and 1, 2 towards the right Hand, and 11, 10, 9, *&c.* towards the left Hand as far as the Hours extend.

Note, It is beſt in drawing this or any other Dial, to draw all the preparative Lines with Charcoal, or Black Lead, or the like, that they may be taken clean out, when you have put on the Hour-lines, and ſuch other Furniture, as you think fit to put upon your Dial.

I might proceed to ſhew the Method of making Inclining Dials declining from the South-weſtward, as alſo North Recliners declining Eaſt and Weſt, but they being all, (with a little Conſideration) included in this, I ſhall only for the making of them give theſe general Rules.

1. AN Incliner declining from the South-Eaſtward, is what we have juſt now ſpoke of.

2. THE Incliner declining to the South-weſtward, is done by the ſame Directions, only the Quadrant which in the Eaſt Decliners is on the right Hand Quarter below the Horizon, muſt in the Weſt Decliners, or thoſe that decline from the South-weſtward, and alſo incline, be in the left Hand Quarter below the Horizon or Line W E, which may be beſt conceived by ſuppoſing this Dial to be drawn on oyl'd Paper, and looking through the Paper, that which on the right Side of the Paper was an inclining Dial declining from

the South-Eaſtward, will, (looking thro' the Paper) be an inclining Dial declining from the South Weſtward, *&c.*

3. A North declining Eaſt Recliner is the ſame of a South declining Eaſt Recliner, only the Horizontal-line W E muſt be at the Bottom of the Dial, and the Quadrant deſcribed thereon upon the Center A, muſt be above the Line E W, and towards the left Hand, and may be repreſented by a South declining Eaſt Recliner turn'd Bottom upwards with the ſame Side towards you as before.

4. A North declining Weſt reclining, is the ſame with a South declining Weſt inclining, only (as before) the Horizontal Line E W muſt be at the Bottom, together with the Center of the Dial, and the Quadrant muſt be above the Line, and towards the right Hand, and may be repreſented by the Dial already deſcribed, if imagined to be done upon oyl'd Paper, and ſeen through being turned Bottom upwards; but of this ſee more, *Chap.* 27. *Page* 110 and 111.

Note, The Hours on the North Dials muſt be numbred the contrary Way to thoſe of the South Dials, and for what Hours to put upon any North Dial, whether declining, reclining, *&c. See Chap.* 1. *Sect.* 10. *Page* 189.

I have not drawn the Hour-lines in the Dial now deſcribed, leſt it ſhould too much confuſe the Scheme, it being eaſy to imagine, where they will fall, when drawn from the Center A thro' the Marks * * *, *&c.* in the Tangent-line.

SECTION XI.

A very plain and eaſy Way to make a Dial, that ſhall give the true Hour by Reflection on a Cieling, where the direct Beams of the Sun can never come, and ſhall repreſent the Sun's Motion as true and regular within the Houſe, as his natural Motion is without, provided the Window open to the Southward, or ſo that the Sun may ſhine in or near it.

TAKE a piece of clear Looking-glaſs, about three Quarters of an Inch broad, and fix it in a Window that looks to the Southward, (the nearer the Out-ſide of the Window that it ſtands, the longer the Sun will ſhine upon it, and therefore it would be better to make ſome Conveniency to place it upon, quite without the Window, that the Sun may ſhine upon the Glaſs as long as it ſhines upon the Wall) and take care to place your Glaſs very exactly parallel to the Horizon, for if you miſtake in that, you throw all the Work amiſs. This done, hold a Thread with a Plummet exactly over the Glaſs, and obſerve where the Shadow of the Thread falls upon the Floor exactly at Noon, and there draw a Line quite croſs the Floor as far as you can, for this will be a true Meridian, or North and South Line; but if you have the Opportunity of a good Clock, Watch, or Dial, you may find the true North by the Directions given, *Page* 224, and 225. and having by any Means found the true North from the Glaſs, and thereby deſcribed a Line upon the Floor, or (which is the ſame)

ſame) ſtretch'd a Thread directly North from the Glaſs; take a Thread and Plummet, (the Plummet having its lower End brought to a Point) and holding your Hand up againſt the Cieling, with the Thread in your Hand, and the Plummet playing freely, move your Hand to and fro, till the Point of the Plummet reſt over or upon the Thread or Meridian-line before found, and there where the upper End of the Thread toucheth the Cieling, make a Mark. Do the ſame at the other End of the Thread or Meridian-line upon the Floor, and make another Mark upon the Cieling; then with a Carpenter's Line, or a ſtrait Ruler, draw a Right-line between thoſe two Points, which will be a true Meridian, or North and South Line, upon the Cieling. Then becauſe the Sun's Meridian Altitude, when in the Equinoctial, is equal to the Complement of Latitude of the Place, and becauſe the Angle of Reflection is always equal to the Angle of Incidence, *viz.* a Line imagined to be drawn from the reflected Spot upon the Cieling, to the middle of the Glaſs, makes always the ſame Angle with the Plain of the Glaſs, that a Line drawn from the Sun to the ſame would do, it will follow, that the Equinoctial muſt croſs the Meridian juſt in that Point that makes an Angle with the Plain of the Glaſs equal to the Complement of Latitude of the Place, which Point in the Meridian may be thus found.

CAUSE one Perſon to hold a Thread exactly upon the Middle of the Glaſs, and ſtretching it tight, hold the other End up to the Meridian upon the Cieling, to make (as near as you can gueſs) an Angle with the Horizon equal to the Complement of Latitude; and holding it there, apply the Side of a Gunter's Quadrant to it, if it make too great an Angle, (keep that End faſt upon the Glaſs, and) ſlip a little more of the Thread out of your Hand, and ſo moving gently to and fro, find where it makes juſt the required Angle (as ſuppoſe of 38½, if it be for Latitude 51½ deg.) there make a Mark in the Meridian upon the Cieling, for there the Equinoctial muſt croſs it; therefore through that Mark draw a Line croſs the Cieling at right Angles, with (or perpendicular to) the Meridian, to repreſent the Equinoctial.

Note, It may be as well to put the Thread thro' the Holes in the Sights of the Gunter's Quadrants, and letting the Plummet play freely, proceed as before.

KEEP your Thread ſtill faſt, one End in the middle of the Glaſs, and the other End in the Point, where the Equinoctial cuts the Meridian in the Cieling, turn your Quadrant with its Center to the Center of the Glaſs, and its Side or Semidiameter exactly along by the Thread, propping or otherwiſe ſecuring it that it may not ſtir, then (becauſe every 15 Degrees of the Equinoctial is an Hour of Time) remove the String 15 Degrees of the Quadrant, and obſerve where it cuts the Equinoctial, when ſtretched to it, and there make a Mark; do the like for the next Hour, removing the Thread to 30 Degrees, and ſtretching it to the Equinoctial, make a Mark, where it cuts it; do the like at 45 deg. 60, *&c.* as far as you can, which done, remove your Quadrant to the other Side of the Meridian, and ſetting of 15, 30, 45, 60, *&c.* Degrees, make Marks on the other Half of the Equinoctial, and ſo you have the Points where the Hour-lines interſect the Equinoctial, which are to be numbred with 12, where the Meridian cuts the Equinoctial, and from thence Eaſtward with 1, 2, 3, *&c.* and Weſtward with 11, 10, 9, *&c.* as far as the Room extends.

Note, You may continue the Equinoctial down by the Sides or Walls of the Room, as well as upon the Cieling over it; if you continue the Quadrant at the aforeſaid Elevation, and continue the Equinoctial down the Wall, ſo as that it may juſt coincide with the Plain of the Quadrant, which may be done by continuing the Thread parallel to the Plain of the Quadrant till it touch the Wall; and though the Wall be never ſo irregular, the Equinoctial may be by this means continued, and the Hours upon the Wall as well as the Cieling may be found by every 15 deg. removing the Thread.

As for the *Hour-lines*, they are to paſs thro' theſe ſeveral Points found in the *Equinoctial* by the aforeſaid Means, but they muſt not cut the *Equinoctial* at *right Angles*. To find the Center, or Point of Interſection of the Hour-lines will be difficult, becauſe it falls without the Room in the Air; for as the Equinoctial is elevated equal to the Complement of Latitude, ſo the Pole is elevated equal to the Latitude; and as the elevated Pole is to the Northward from us, and a Line ſuppos'd to be drawn from it to the Center of the Glaſs, will make with the Horizon an Angle equal to the Latitude of the Place, ſo the reflected Axis of the World ſhall deſcribe an infinite Line in the Air to the Southward, making with the Horizon the ſame Angle.

But becauſe the Pole or Center of the Equinoctial falls without in the Air, it is not ſo eaſily acceſſible for drawing the Hour-lines; therefore to remedy that Inconveniency, obſerve by the Directions given, (Sect. 1.) *For drawing an Horizontal Dial*, what Angle every Hour-line makes with the Meridian, and in this Caſe, they muſt make an Angle equal to the Complement of the ſame Angle with the Equinoctial. As for Example.

Suppose I would make an Horizontal Dial for Latitude 51 Degrees, 32 Minutes North. I ſhall find by the Directions given, Sect. 1. that the Hour-lines make Angles with the Meridian, as followeth.

			d.	m.
12			0	0
11	1		11	50
10	2		24	20
9	3	makes an Angle of	38	3
8	4		53	35
7	5		71	6
6			90	0

These are the Angles that each Hour-line makes with the Meridian; their Complements to be made with the Equinoctial, are,

For		The Angle with the Equinoctial is	
12		90	0
11	1	78	10
10	2	65	40
9	3	51	57
8	4	36	25
7	5	18	54
6		0	0

THEREFORE, if through the ſeveral Points found in the Equinoctial for the Hours, you draw Lines to make the laſt before-mentioned Angles with the Equinoctial, they ſhall be the ſeveral Hour-lines required, and the Sun ſhining upon the Glaſs ſhall reflect the Light at any Time of the Year upon the Hour of the Day.

> *Note*, What is ſaid here of the Angles which the Hour-lines make with the Equinoctial, is meant while the Equinoctial is continued upon the Cieling parallel to the Horizon, and not with Reſpect to its being continued down the Wall.

⁂

SECTION XII.

How to make a Line of Chords, whereby any Number of Degrees may eaſily be ſet off upon any Circle, without the fore-mentioned Trouble of dividing it.

DESCRIBE a Semicircle, and divide the Circumference of it exactly into two equal Parts at c, then divide either of the Quadrants (as ſuppoſe b c) into 90 equal Parts, as you are directed in the firſt Section of *Mechanick Dialling*, and you may draw the Line b c. Then upon the Plain where you intend to make your Line of Chords (whether upon a Ruler, a Paper, or Board) draw a handſome double Line and a ſingle Line at a competent Diſtance from it, ſo as to leave Room between them for the Figures, as you ſee *Fig.* 8. and let theſe Lines be exactly the Length of the Line b c, from A to B, which done, and the Quadrant very carefully divided into 90 equal Parts, as before directed, take a Pair of Compaſſes, and placing one Foot in the Point b, extend the other to the End of the firſt Degree, and keeping that Extent, place one Foot in the End of the double Line at A, and make a Mark where the other falls in the ſaid Line; then again placing one Foot in b, as before, extend the other to the End of the ſecond Degree, and ſet the ſame Extent on the Line A B from A towards B, and where

Plate 12.
Fig. 8.

where that falls make another Mark. Proceed in the ſame Manner with the third, fourth, or fifth Degrees, *&c.* till you have thus transferred all the 90 Degrees of the Quadrant to the Line A B, (which if right done, will be unequal upon the Line A B, being largeſt at firſt, and leſſening gradually towards the laſt) always obſerving at every Tenth Degree, as 10, 20, 30, *&c.* to carry the Diviſion, through the ſingle Line, and upon theſe Diviſions place the Numbers 10, 20, 30, *&c.* for the more immediate Number of the Degrees, the intermediate Degrees between every 10, being to be numbred from the next leſs even ten, as the third ſmall Diviſion beyond 30 is 33, *&c.* and then is your Line of Chords finiſhed.

It is always obſerved, that the Chord of 60 is equal to Radius, that is, when a right Line is truly divided by theſe Directions, the Extent from the Beginning of the Line at A to the 60 Degree, is juſt equal to g b the Semidiameter of the Circle, by which the ſaid Line was divided; therefore in Practice, whenever you would draw a Circle, that you propoſe to divide by your Line of Chords, it muſt always be a Circle of the ſame Bigneſs of that, by which your Line of Chords was made, in order to which, whatſoever Line of Chords you intend to work with, take 60 Degrees of the Chord, (that is, the Extent from the Beginning of the Line to 60) and with that Extent, and one Foot where you intend to make your Center, ſweep a Circle, or a half, or a quarter of a Circle, as you may have Occaſion, and when you have any given Number of Degrees to ſet upon the Circle, from any given Point, extend your Compaſſes from the Beginning of the Line of Chords to the Degree propoſed, and with that

Extent, and one Foot in the given Point, obſerve where the other Point falls upon the Circle, and make a Mark; for that is the Number of Degrees required.

EXAMPLE.

It is required to ſet 37 Degrees upon the Quardrant d c, from d towards c. Place one Foot of your Compaſſes in the Beginning of the Line of Chords at A, and extend the other to 37 Degrees, (*viz.* to ſeven ſmall Diviſions beyond the Number 30) then with that Extent applied to the Circle, one Foot in the given Point d, the other will reach to n, the Quantity of 37 deg. required.

To meaſure a given Arch of a Circle, is juſt the Reverſe of this; for, take the given Arch, or the Diſtance between the two given Points in a Circle in your Compaſſes, and apply that Extent upon your Line of Chords, (always putting one Foot upon the Beginning of the Line) the moveable Foot falls upon the Degree required.

EXAMPLE.

It is required to meaſure the Arch d n in the Semicircle d c b. Place one Foot of your Compaſſes in d, and the other in n, that Extent apply'd to the Chords, gives 37 deg. *&c.*

But no Line of Chords will meaſure any Circle, but thoſe of the ſame Diameter with that from whom the Line is projected; therefore it may be proper to make or have Lines of ſeveral Radius's; but if you have not ſuch Variety, that Deficiency may be in ſome Meaſure remedied thus:

To meaſure any Part of any Circle, (whether it be to a larger or leſſer Radius than your Chords are made for, it matters not) take in your Compaſſes the Chord of 60 deg. from your Scale, and with one Foot in the Center of the Circle that is to be meaſured, draw a Circle which will be parallel to the Circle to be meaſured, but whether within or without, it is the ſame; but in this Caſe, we will ſuppoſe it falls without the Circle that you would meaſure. Lay a ſtrait Ruler from the Center to the Point, from whence your Number of Degrees is to be ſet off, and obſerve where it cuts the Circle laſt drawn, and make a Mark, from which ſet the given Number of Degrees, and where the Degrees end, and from the Center, lay a Ruler, and obſerve where it cuts the firſt Circle; for between that Point, and the Point firſt propoſed, is the Number of Degrees required to be ſet off.

EXAMPLE.

Plate 12. *Fig.* 8.

In the Semicircle x y z, it is required to ſet off 37 deg. from x towards y, but having no Chord to that Radius, take the common *Chord*, and with the Sweep of 60, draw the Circle d c b, upon which ſet 37 deg. from d to n, and laying a Ruler from the Center to n, it cuts the inner Circle in o, and the Arch x o in the leſſer Circle, is equal to d n in the greater, *viz.* 37 deg. as required.

I ſpeak of meaſuring or ſetting off promiſcuouſly, one being the Reverſe of the other, and further Repetitions would be needleſs.

But the beſt Way of dealing with Circles of different Radius's, is by a Sector, whereon you have the Chords commonly marked C, which proceed from the Center to (near) the End of the ſame Side of both Legs, being exactly graduated alike; and in Order therewith to meaſure any Part of any Circle of what Diameter ſoever, Firſt, Take in your Compaſſes the Radius or Semidiameter of the Circle, then open your Sector to that Wideneſs, that the Compaſſes (kept as they were) may reach from the Braſs-point at 60 on one Leg of the *Sector*, to the Braſs-pin or Point at 60 on the other Leg thereof; then if you would ſet off any Number of Degrees (ſuppoſe 45) from any Point in the *Periphery* of the ſaid Circle, keeping your Sector at the ſame Opening, extend your Compaſſes from 45 on one Leg to 45 on the other, that Extent contains 45 Degrees of that Circle, and placing one Foot where the Leg in the other will find the Point where they end; and the ſame Method is to be uſed for Circles to any Radius or Arches containing any Number of Degrees.

* * *

SECTION XIII.

How to make a Dial that ſhall give the true Hour of the Day, without a Stile or Gnomon, only by the Shadow of one Part of it appearing upon another Part thereof.

THERE is one of this Sort of Dials near the *South West* Corner of *Middle Moor-fields*, and in ſome other Places in *London*; but for the making of them, you need have no Regard to the Latitude of the Place, for that is to be conſidered in the placing, and not in the making of them; in order to which, prepare a Piece of Wood, Braſs, or Iron, of Bigneſs at Pleaſure, in the Form of a Croſs, having one of the Four-ends longer than any of the other three, and let the Thickneſs of it be about equal to the Length of one of the ſhorteſt Ends, as you ſee in the Figure a b c d e f g h i k l m, where b c and c d and l m are ſuppoſed equal, and f g equal to h i, is longer than any of them; then for finding the Hours, take a Piece of plain Plank, or Wainſcot, as long as the Line f g, and as broad as the Length of the Line c d is intended to be in your Dial; ſuch a Piece is exactly repreſented by Parallellogram, or long Square, f g h i, and which indeed may ſerve for the Purpoſe following.

Plate 12. *Fig.* 9.

TAKE the Extent f i, or h g, (which are equal) in your Compaſſes, and with one Foot in i, the very Interſection of the Side k e with the Side a h, and draw the Qudrant f n, which divide into 6 equal Parts for 6 Hours, becauſe it is a Quarter of a Circle; and where theſe equal Diviſions fall, make the Marks * * *, &c. A Ruler laid from the Center i, through the Marks * * *, &c. will cut the Line f g in the Points r x z, &c. then the Poſition of this Dial being to be with the End a b, to face the South, and the upper Part of the Dial to lie parallel to the Equinoctial, (not to the Horizon) the Sun at 12 a Clock will ſhine juſt along the Line a m or b c; and therefore place 12 at m and c, then it is plain, that from 12 to 3, the Shadow of the Corner a will paſs along the Line m l; therefore take from your Projection the Diſtance f r, and place from 12 to 1. Take alſo f x, and place from m to 2, and the Diſtance f z will be equal to m l; therefore, at l place 3, and at 3 in the Afternoon the Shadow of the Corner a, will go quite off the Side l m, but the Shadow e will be come upon the Line f g as high as z; therefore at z place 3, and at x place 4, and at r place 5, and then 6 muſt be in the Corner f, becauſe at 6 the Sun will ſhine right along the Line e f; place 6 alſo at the Corner c, becauſe the Sun at 6 ſhines right along the Line c d, and from 6 till 9 (if it be in a Latitude where the Sun continues up ſo late) the Shadow of the Corner at d is paſſing along the Line c b; therefore take in your Compaſſes the Diſtance f r, and ſet from 6 to 7. Take alſo f x, and ſet from 6 to 8, and the Diſtance f z is equal to c b; therefore at the Corner b place 9, becauſe the Shadow of the Corner d goes off the Line b c at 9. Then for the Morning Hours, the Shadow of the Point l will enter upon the Line a m at the Point a, juſt at 3 in the Morning; therefore draw Lines from 7 and 8 in the Line b c, which let be drawn parallel to a b, or m c, and having placed 3 at the Corner a, place 4 upon the End of the Line that comes from 8 and 5, upon the End of the Line that comes from 7, and then 6 will be in the Corner m, becauſe at 6 the Sun ſhines juſt along the Line l m, and from 6 till 9 the Shadow of the Point k is paſſing along the Side i h; therefore having placed 6 in the Corner i, draw Lines from the Points r x z parallel to g h, and at the other End of theſe Lines, *viz.* upon the Side i h, place the Hours of 7, 8 and 9, and when the Shadow of the Point k comes at 9, the Shadow of the Point b is at the Point d, and from 9 to 12, the Shadow of b paſſeth along the Line d c, and at 12, the Shadow of b is come to c; therefore take the Diſtances f r, f x, and f z, and ſet from e to 11 and 10, the Diſtance f z being juſt equal to c d, and then is your Dial finiſhed; the Sun, as it goes off from one Part of it, comes on to another, ſo that the Time of the Day may be always found upon ſome Part or other of it, when the Sun ſhines.

THE Reaſon why theſe Dials require Thickneſs, as well as other Dimenſions, is, becauſe being placed parallel to the Equinoctial, the Sun ſhines upon the upper Face all the Summer, and at the Longeſt Day is elevated 23½ deg. above the Plain of the Dial, and conſequently the Shadow of a, will fall at Noon in the Line a m, but not in the Point m, but at an Angle of 23½ deg. therewith, which muſt be accounted for in the Thickneſs of the Body of the Dial.

Note, It is not neceſſary that any of the Ends of the Dial ſhould be longer than another, only for Ornament; but if you would make one of thoſe Dials for any Place beyond the Artick or Antartick Circles, where the Sun is ſometimes ſeen all the 24 Hours, it is neceſſary all the Ends ſhould be alike, becauſe then the Sun would come on to one Part as it goes off from another continually, which now it cannot; for the Sun coming up in the Morning, the Shadow of g would have quitted the Line f e at e, before the Shadow of l would come on to the Line a m at a; but if f g was cut off at z, and f z made equal to a m, or m l, &c. the Shadow of z would juſt quit e when the Shadow of l enters upon the Line a m at a.

The Sun's Place or Declination may be inſerted in theſe Dials as eaſily as in any; for if you take in your Compaſſes the Extent a m, and with one Foot in the Point or Corner a, and with the other ſweep an Arch from the Corner at m downwards, and with that from a Chord to the ſame Radius, ſet off every 5 or 10 Deg. of Declination, or the Sun's Declination at his Entrance into each of the Twelve Signs, being ſet off upon the Circle, and Lines drawn through theſe Marks to the Corner under m, and from thence parallel to b m, and c d will give the Sun's Entrance into the 12 Signs by the Shadow of the upper Point a, in the Summer Seaſon, while the Sun ſhines upon the upper Surface of the Dial; but in the Winter, the like Method muſt be uſed with the lower Part for the Southern Sign, the Declination increaſing upwards, and decreaſing downwards.

The Sun's Declination at his Entrance into the 12 Signs, is as followeth.

North Declination.				South Declination.			
		d.	m.			d.	m.
♈	Aries	0	0	♎	Libra	0	0
♉	Taurus	11	30	♏	Scorpio	11	30
♊	Gemini	20	12	♐	Sagittarius	20	12
♋	Cancer	23	30	♑	Capricornus	23	30
♌	Leo	20	12	♒	Aquarius	20	12
♍	Virgo	11	30	♓	Piſces	11	30

In making theſe Dials, there is no Regard to be had to the Latitude of the Place; that being to be conſidered in placing them, which muſt be done ſo, that the upper Face of the Dial may be juſt

parallel

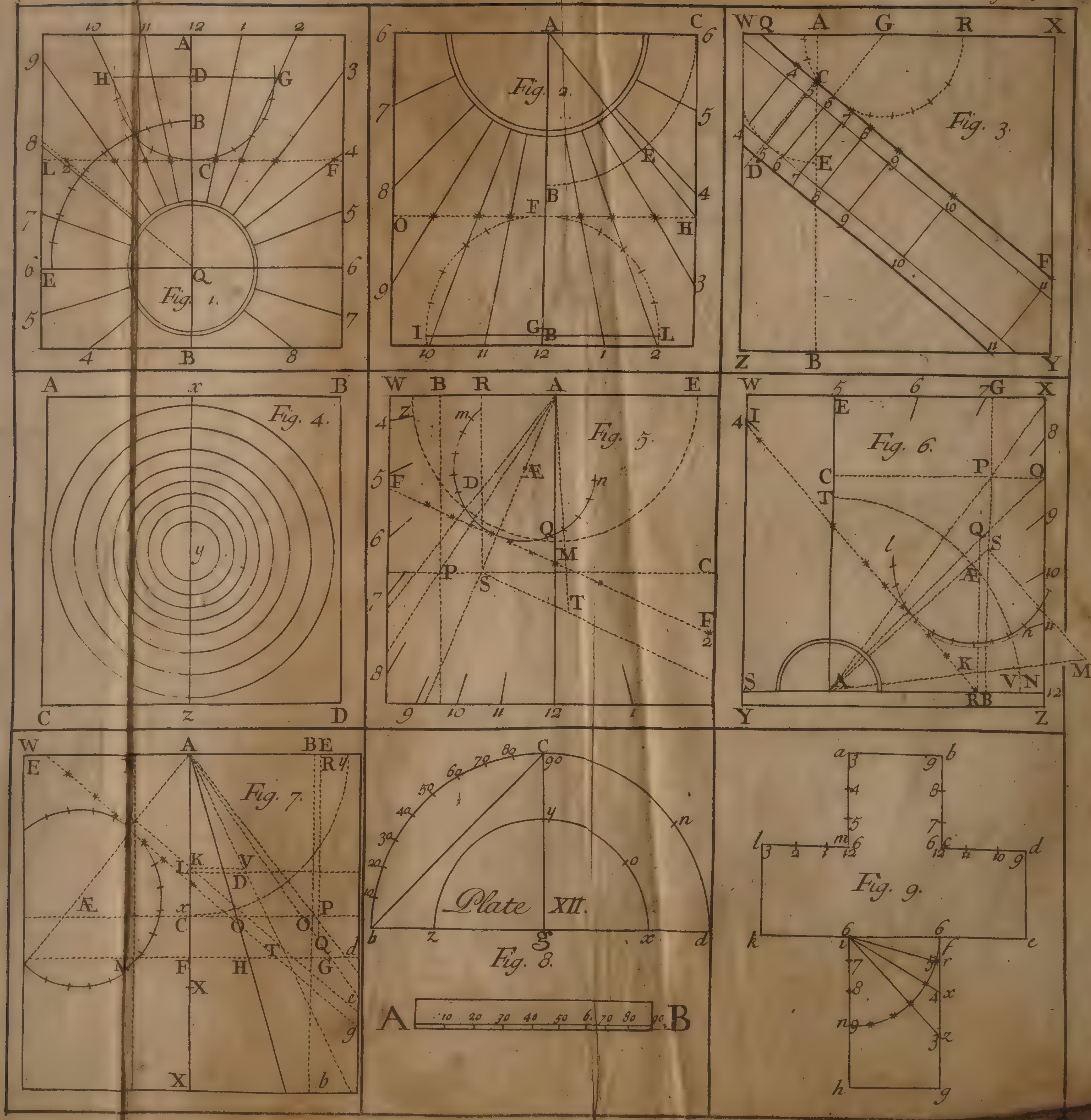


Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.

Plate XII.

Fig. 8.

Fig. 9.

parallel to the Equator, the Line a m and b c, pointing at the South Part thereof; in Order to which, having found the Meridian of the Place, ſet the Dial exactly North and South, and lay a ſtrait Ruler along the Middle of the Dial, from h g to a b, letting it hang over at the End a b; then on the under ſide of that Part of the Ruler that hangs over, fix a Gunter's Quadrant with one of its ſtrait Sides to the Ruler, and the Center towards the End of the Ruler; which done, elevate the End a b of your Dial by little and little, till the Plummet (having free Liberty to play) falls upon the Complement of the Latitude of the Place; or, (which is the ſame) till the Plain of the Dial make an Angle with the Horizon equal to the aforeſaid Complement of Latitude; then is your Dial fit for Obſervation, there being always ſome Side of it, upon which the Hour of the Day may be ſeen, if the Sun ſhines.

CHAP. XII.

Of Painting of DIALS.

SECTION I.

1. *How to prepare your Oyl for laying on the Colour upon Dials.*

TAKE one Gallon of Linſeed Oyl, and ſet it upon a Charcoal Fire, and when it is about to boil, put into it two Pound of Red-lead, and let it boil together for about an Hour; but the beſt Way to know, when it is boiled enough, is to take a little of it out, and let it cool, and then if it roaps like thin Tar, it is enough. This done, put a lighted Paper to it, and ſet it on Fire, to conſume the greaſy Part of it, which will be done in a Minute or two, or more or leſs, according to the Quantity of your Oyl; and when it has burnt long enough, clap a Cloth, or any other thing cloſe over it, and extinguiſh the Fire; after which let it cool and ſettle, then decant the clear Oyl from the Dregs, and keep it in a Bladder for uſe.

THIS is called drying Oyl, and with this the ſeveral Colours are to be ground, in order to paint, ſo as to endure the Weather, (being firſt dry, before it be expoſed) the ſeveral Colours we ſhall deſcribe hereafter.

2. *How to make Gold Size, with which to lay on Leaf Gold.*

TAKE yellow Oker, and grind it with Water on a Stone, with a Muller, till it be very fine, and then lay it to dry, and grind it with the aforementioned drying Oyl, as you would grind other Colours, obſerving to put ſo much of each that it may be of competent Stiffneſs to work well, and of ſuch a Body, that it may ſettle itſelf ſmooth when laid on, but not ſo thin as to run; and take Care to grind it very fine, and it will add the greater Beauty to your Gold that is to be laid on with it.

* * *

SECTION II.

Of Colours uſed in painting Sun Dials.

THE Colours generally uſed in painting Sun-Dials, are,

1. FOR *White*, Ceruſe and White-lead.
2. FOR *Black*, Lamp-black, Ivory-black, Charcoal and Seacoal-black.
3. FOR *Red*, Red-lead, Vermilion, and Cinabar Lake.
4. FOR *Green*, Verdigreaſe.
5. FOR *Blew*, Indico, blue Bice, blue Verditer, and Smalt.
6. FOR *Yellow*, Yellow Oker and yellow Pink.
7. FOR *Brown*, *Spaniſh* Brown.

Of theſe Colours you may compound Variety of other Colours, as,

1. A little Lamp-black with White, makes an Aſh-colour.

2. CINNABAR Lake is a rich Crimſon Colour, but mixt with Bice, it makes a fine Purple, according to the Proportion of Mixture; but mixt with White, it makes a fine Carnation.

2. BLEW Bice mixed with yellow Pink, makes a Green; with Lake a Purple; and with White a light Blue And note, that any Blue and Yellow mixed, make a Green of ſome Sort or other.

4. INDICO mixed with White, makes a Lead Colour.

VERDIGREASE mixt with Yellow Pink, makes a lively Graſs-green.

BY this Means may ſeveral other Colours be compounded, and made lighter or darker, at Pleaſure, as a little Practice will make evident.

* * *

SECTION III.

How to prepare the Colours for Painting Sun-dials.

BEFORE you proceed to the painting of Sun-dials in their ſeveral Colours, it is firſt neceſſary that they be primed; that is, painted two or three Times over with Oyl and Colour, prepared for that Purpoſe, to fill up the Cavities, which may (after plaining) remain in the Wood, and to make it pefectly plain, and the more capable to receive and retain other Colours; and of all priming, *Spaniſh Brown* is reckoned to be the chief; for, not to mention its Cheapneſs, it dries kindly, and gives the Oyl ſufficient Time to penetrate into the Wood, and conſequently alſo reſiſts the Weather, and alſo freely receives all other Colours which are laid upon it. It is of itſelf of a Horſe-fleſh-colour, and (beſides its Uſefulneſs in priming) it is a natural Shadow for Vermilion, and may be made lighter or darker, according to the greater or leſs Quantity of White mixt with it; but in priming, it requires not any Mixture, but only the Oyl it ſelf.

In preparing the *Spaniſh Brown* for priming, grind it very well with the afore-mentioned drying Oyl, and make it for the firſt priming, ſomewhat thinner than you would do it for painting, that it may more eaſily penetrate into the Wood; which being dry, do it over again with the ſame Mixture, only mix it a little thicker; and letting that dry, do it a third Time, mixing your Colour thicker every Time. And take Care in the priming not only to rub the Bruſh with the Priming upon the Dial, but alſo bob it againſt it, that the Priming may be ſure to pierce into all the Cavities or Pores of the Wood. This done, and your Dial dry, the third Time it is ready for laying on the Colours, *viz.* painting the Hour-lines, or what Ornament or Furniture you think fit to have upon it.

If you are but for making a common Sun Dial, theſe four Sorts of Colours will be ſufficient.

1. *Spaniſh Brown*, which prepare, and therewith prime your Dial, as before directed.

2. *White-lead*, well ground in Oyl, with which after the Priming is thoroughly dry, go over it three or four Times, letting it dry between every Time; which not only makes a beautiful white Ground, but fortifies it yet more againſt the Fury of the Weather.

3. *Lamp-black*, for drawing the Hour-lines and Figure.

4. *Vermillion*, for drawing the Parallels of Declination, or what other Furniture you think fit to put upon it.

The *Spaniſh Brown*, *Lamp-black*, and *Vermillion*, are all to be ground in the drying Oyl, deſcribed at the Beginning of this Chapter; and for the *White-lead*, it is to be uſed in the ſame Manner, only in making drying Oyl for White-lead, inſtead of Red-lead, uſe Litharge of Gold, and proceed as before.

But if you would have your Dial more rich, you muſt firſt conſider, what Colours you reſolve to have your Lines, Figures, &c. to be; and upon what Ground your determined Colours will appear moſt beautiful, as,

1. Gold appears beſt upon a blue Ground, and indifferently upon a Red.

2. Blue and Green appear beſt upon Yellow and White.

3. Red ſets off with Yellow, White, Blue, or Green.

4. Yellow ſets off with Black, Blue, and Red.

Besides the Directions given already for preparing and laying on common Colours, it will be neceſſary to ſpeak of the laying on the more rich and beautiful Colours; and firſt,

How to lay on Leaf Gold, or to make any Lines, Figures, &c. of Leaf Gold upon your Dial.

Draw your Lines, Figures, or Letters, (or what you think fit to have in Gold) with Gold-ſize; (of which before) which let dry ſo, that when you touch it with your Finger, it will ſtick, but not come off; then cut your Leaf Gold, as near as you can, into the Form you would have it, whether of Figures, Letters, Lines, *&c.* (taking Care to cut it rather too large, than too little) and with a flat Stick lin'd with Cloth, take up your Gold (ſo cut) and put it upon the Size, and the Gold will leave your lin'd Stick, and cleave to the Size; then preſs it down with Cotton, or a Hare's Foot, and take care that you make the Figures, Lines or Letters, in the Gold-ſize, and that you cut the Gold large enough to cover the Figures ſo made in the Size; and when it is thoroughly dry, bruſh off all the looſe Gold, and the Painting will remain beautiful, and be able to endure the Weather.

How to lay on Smalt, to make a fine Blue.

When you have laid on what you think fit in Leaf Gold; take White-lead, mix it pretty ſtiff with drying Oyl, and with a Pencil lay that on, where you intend your Blue ſhall be, and then put your Smalt in a fine Searce, and ſift it on to the Dial, and with a Piece of Cotton, dab it down upon the White before laid on, and when it is thoroughly dry, wipe off all the looſe Colour with a Feather, and blow off the Duſt with a pair of Bellows, which will eaſily blow off, except what fell upon the White before laid on to retain the Blue, which will be a very beautiful Blue.

OBSERVE as a general Rule, that Priming is to be mixt or temper'd thin, but Colours for Lines or Figures to endure the Weather, muſt be temper'd thicker, the better to reſiſt the Fury of ſtormy, or moiſt Weather.

SECTION IV.

Of the Nature and Colour of ſome of the principal Ingredients uſed in painting of Sun-Dials.

1. CERUS and *White-lead*, are the only Colours to be uſed in painting in Oyl, and beſides their Uſefulneſs in painting of Dials, Paint made up with them and Oyl, is frequently made uſe of in painting Poſts, Paliſadoes, Gates, Doors, Windows, Wainſcoting, *&c.* and anſwers the End of Painting, both as to Beauty and Preſervation; for they dry well, and ſtrongly reſiſt the Weather. But if you would have them to dry yet more ſpeedily, you may in the Tempering put in a little Oyl of Turpentine, if it be within Doors, but without Doors it is better without, becauſe that does not ſo well reſiſt the Weather.

2. *Lamp-black* is a good Black, if it be firſt burnt, then ground, and laſtly tempered with Oyl.

3. *Charcoal* is a Black that will ſerve for ordinary Uſes; it dries well, but great Care muſt be taken that it be well ground.

4. *Spaniſh Brown*, the beſt is a deep bright Colour, and free from Stones, and being very well ground, is the beſt for priming: It is of a Horſe-fleſh Colour, and a proper Shadow for Vermilion.

5. *Red-lead* is a great Dryer and Binder; for which Reaſon, it is made uſe of in the drying Oyl; it reſiſts the Weather as well as any Colour whatſoever.

6. *Vermilion* is a rich Colour, and of a good Body, but care muſt be taken that it be finely ground, even as ſoft as Oyl, and then it will work extraordinary well: It is beſt to buy it in the Stone, leſt you meet with ſome that has been adulterated with Red-led, or the like; it is a perfect Scarlet of it ſelf, and may be altered to ſeveral Varieties, by mixing with other Colours.

7. *Cinnabar-lake* is a rich Crimſon Colour, and muſt be very fine ground.

8. *Smalt* is a very fine Blue, and it is beſt to be ſtrewed on, as before taught; for if you work it in Oyl, (though you waſh it, and mix it with White-lead) yet it will turn black in Time. If you buy it to work in Oyl, the fineſt is beſt, which is call'd *Oyl-Smalt*.

9. *Blue Bice* is a pale Colour, and works well though a little ſandy.

10. *Blue Verditer* is not ſo good a Blue as *Bice* and *Smalt*, though it may ſerve in Dial-painting,

where they are wanting; it is a little ſandy, and apt to fade and turn greeniſh.

11. *Indico* is a very dark Blue, and commonly lightned with White, when us'd in Painting, except in Shadowing; it grinds fine, and is very proper for the laſt Colour of Poſts, Paliſadoes, Doors Windows, *&c.* for it reſiſts the Weather, and preſerves the Wood.

12. *Blue Balls* are almoſt like Indico, but not ſo good a Colour, nor will it endure ſo long.

13. *Umber* is a Hair Colour, it muſt be very fine ground, which to effect, requires a great deal of Labour; it dries and binds exceedingly, and is therefore alſo very proper for painting without Doors, as Doors, Paliſadoes, *&c.* if calcin'd in a *Crucible*, it is a natural Shadow for Gold, and ſome other Colours,

14. *Verdigreaſe* is a perfect Willow-green, but may be altered at Diſcretion, with Yellows, *&c.* but being very foul, it muſt be mended or cleanſed; which may be thus done: *Grind it fine, and put to it eight Times its Weight of Spirit of Vinegar; digeſt till the Vinegar is tinged very green, then decant the Colour; caſt away the Fæces, and evaporate the Vinegar in a Braſs Veſica; ſo have you a very good Verdigreaſe at the Bottom, much more fine and valuable, than before it was cleanſed.* It dries very ſpeedily.

15. *Yellow Oker*, the *Engliſh*, the Colour of a freſh Wheat Straw; the foreign is ſomewhat more deep a Colour; it is much uſed in common Painting, being ground very fine.

16. *Yellow Pink* is a greeniſh Yellow; it grinds well, and is good to mix with other Colours, to make a Green.

OF theſe Colours, ſome require waſhing, as *Red Lead*, *Blue Bice*, *Smalt* and *Verditer*; which is thus performed:

PUT the Colour into a glazed Veſſel, and put thereto plenty of clear Water, waſh it well, and (after a while) decant the Water. Repeat this Work ſix or ſeven Times; at laſt (the Water being but juſt troubled) put it into another glazed Veſſel, leaving the Dregs at the Bottom; then put ſome more Water into this ſecond Veſſel, and waſh it as before, till the Water after ſettling be clear, and the Colour remain fine at the Bottom.

Note, Before you take the Colour out of the Veſſel, ſpread it about the Sides of the Veſſel very thin; and when it is dry, it will part of it fall down to the Bottom, which keep by it ſelf; but that which ſticks to the Sides of the Veſſel is the beſt, and is as fine as any Flower, that ſtrike off with a Feather, and keep it for Uſe.

THE Colours that require waſhing being thus prepared, (or if they are thoſe that do not require waſhing, they are done without) your next Work is to grind them, which is done thus:

TAKE a Spoonful or two of the Colour you intend to grind, and put to it a little Linſeed-Oyl, (but be careful you put in too little rather than too much); mix them together, and upon your Stone with a Muller, grind them well, adding Oyl by Degrees, as you ſee it requires it, to make it like an Oyntment, (always obſerving, that it grinds much better when it is thick, than when it is ſo thin as to run about the Stone) every now and then ſcrape it up together with a thin Knife, or Lanthern Horn, to keep it at or near the middle of the Stone, and ſo continue to work, till you have ground as much as you have Occaſion for; which done, clean your Stone, by grinding Sand and Water upon it, and then waſh and dry it, and the Muller; and when you go to make uſe of it, mix it with drying Oyl, till it be ſo thin as to run freely from the Pencil, yet ſo thick, that the Ground may not appear through it, or to run when it is laid on, and then it will be the more beautiful Colour, and better endure the Weather.

* * *

SECTION V.

How to make ſome Original Colours, &c.

1. *To make* White-Lead.

TAKE as many Plates of fine Lead as you pleaſe, and then put them into an earthen Pot, or Crucible, fill the Pot with White-wine Vinegar, and cover the Top of it cloſe with Clay, bury it in a Cellar, or ſome moiſt Place, for ſeven or eight Weeks, and there will be White-lead upon the Plates, which wipe off, and keep for Uſe.

2. *To make* Verdigreaſe.

HANG Plates of Copper over the Fumes of Aqua-fortis, or Spirit of Nitre; or dip the Plates in the ſame, or in Vinegar, and the Ruſt or Scurf that is by that Means bred upon the Plates, is Verdigreaſe.

3. *To make* Ultramarine.

TAKE *Lapis Lazuli*, the deepeſt coloured you can get, having few Veins of Gold in it, cover ir cloſe up in a Crucible, and heat it red hot, and then quench it with Urine, Vinegar, or Water, in an Earthen Pot well leaded; dry it well, then with a pair of Pincers pull off the hard, white or grey Parts of it, then grind the reſt very fine with Honied Water, and dry it, and keep it for Uſe.

Note, The Honied Water is made by boiling a Quart of Water with two Spoonfuls of Honey.

4. *How to make the beſt Glue, for gluing the Joints of Boards for Dials, or the like.*

TAKE Milk that hath ſtood ſo long, and been ſcum'd ſo often, that no more Cream will ariſe; and when ſcum'd very clean, boil it a little in a leaden Pot, and if any Cream yet ariſe, be ſure to take it clean off; then put into the Milk a ſufficient Quantity of Glue cut in ſmall Bits, which will ſoon melt: Boil it to a good Body, but not too thick nor too thin; then take it from the Fire, and keep it for Uſe.

Note, You muſt take Care, that in boyling it you do not burn it to the Sides of the Pot, for that takes away much of the Strength of the Glue; but if it be made with due Care, it binds beyond any other Glue, and is better able to reſiſt the Weather; and therefore, the fitteſt for glueing Boards for Sun-Dials, or the like.

5. *How to make an exceeding ſtrong Cement or Plaiſter, with which to form any Dial-plain upon the Side of a Houſe or Wall, and to endure the Weather, not inferior to Stone.*

TAKE Lime and Sand, and temper it with Linſeed-Oyl to the Conſiſtency of Mortar, or common Plaiſter, and ſpread it upon the Wall to a competent Thickneſs, it will become as hard as a Stone, and laſt many Ages; and upon this you may deſcribe a Dial, and put on the Lines, Figures and Furniture, as before directed.

Note, If you are in the Country, remote from any Opportunity of getting Linſeed-Oyl, you may make it with ſcum'd Milk, which will be very ſuperior to Plaiſter made with Lime, Hair, and Water.

HAVING proceeded thus far in Colours for Painting to endure the Weather, it may not be improper to add ſomething of tranſparent Colours for the Colouring of Maps, or any Draughts upon Paper or Vellum; of which, in Order.

Firſt, A Yellow.

THE fineſt that you have Occaſion to uſe, will be your *French* yellow Berries, which ſteep'd in a Gallipot of Water, with a very little Allum, about 12 Hours, makes a very beautiful Colour.

Secondly, A Red.

TAKE a Quantity of Brazil, about four Ounces, and boil in a Point of Grounds of Ale, adding about a Quarter of a Pint of Vinegar, a ſmall Quantity of Gum-Arabick, and about an Ounce of Allum; let them boil very well, and ſtrain the Colour through a fine Linnen Cloth.

Thirdly, A Sea Green.

Take a Quantity of Verdigreaſe, about four Ounces, boil it in a Pint and a half of Water, firſt putting about half an Ounce of Argul to it, let it boil till the Colour ſtains pretty deep.

Fourthly, A Graſs Green.

Is compounded of the Yellow of yellow Berries, and the Sea-Green mixt according to Diſcretion.

The *Fifth*, which is brown, commonly uſed for Roads, Barks of Trees, *&c.* is burnt Umber, which you muſt grind very fine, with ſome Gum-water.

Gum-water is only Gum-Arabick ſteep'd in Water, till diſſolv'd.

A Table of the three Requiſites in Dialling, for Latitude 51 deg. 30 min.

Declination.	*Subſtile's Diſtance Meridian.*		*Stile's Height.*		*Inclination of Meridian.*		*Declination.*	*Subſtile's Diſtance Meridian.*		*Stile's Height.*		*Inclination of Meridian.*	
	d.	m	d.	m.	d.	m.		d.	m.	d.	m.	d.	m.
1	00	48	38	29	01	17	22	16	36	35	16	27	18
2	01	36	38	28	02	33	23	17	16	34	57	28	29
3	02	23	38	26	03	49	24	17	56	34	39	29	38
4	03	11	38	23	05	07	25	18	37	34	21	30	47
5	03	58	38	20	06	23	26	19	12	34	01	31	56
6	04	45	38	15	07	39	27	19	50	33	42	33	04
7	05	32	38	10	08	55	28	20	22	33	20	34	12
8	06	19	38	04	10	11	29	21	05	32	59	35	19
9	07	05	37	57	11	27	30	21	40	32	37	36	25
10	07	52	37	49	12	42	31	22	15	32	15	37	31
11	08	38	37	40	13	57	32	22	50	31	52	38	36
12	09	23	37	30	15	10	33	23	25	31	27	39	41
13	10	08	37	21	16	26	34	23	59	31	04	40	46
14	10	54	37	10	17	40	35	24	31	30	40	41	49
15	11	38	36	58	18	54	36	25	04	30	14	42	52
16	12	22	36	43	20	07	37	25	35	29	48	43	55
17	13	05	36	32	21	20	38	26	04	29	22	44	58
18	13	42	36	18	22	33	39	26	35	28	56	45	59
19	14	31	36	03	23	45	40	27	03	28	29	47	00
20	15	13	35	48	24	57	41	27	33	28	01	48	00
21	15	54	35	31	26	08	42	28	01	27	33	49	00

A TABLE of the three Requiſites in Dialling, for Latitude 51 deg. 30 min.

Declination.	Subſtile's Diſtance Meridian.		Stile's Height.		Inclination of Meridian.		Declination.	Subſtile's Diſtance Meridian.		Stile's Height.		Inclination of Meridian.	
	d.	m.	d.	m	d.	m.		d.	m.	d.	m.	d.	m.
43	28	29	27	5	50	00	67	36	13	14	05	71	38
44	28	55	26	36	50	59	68	36	25	13	29	72	27
45	29	21	26	07	51	57	69	35	36	12	53	73	16
46	29	46	25	37	52	55	70	36	40	12	11	74	06
47	30	11	25	07	53	53	71	36	55	11	41	74	55
48	30	35	24	38	55	50	72	37	06	11	06	75	44
49	30	58	24	06	55	46	73	37	15	10	29	76	33
50	31	21	23	35	56	42	74	37	24	09	53	77	21
51	31	45	23	04	57	38	75	37	32	09	16	78	09
52	32	05	22	32	58	33	76	37	40	08	40	78	57
53	32	26	22	00	59	28	77	37	47	08	03	79	46
54	32	46	21	28	60	23	78	37	57	07	27	80	33
55	33	06	20	55	61	17	79	37	59	06	49	81	21
56	33	24	20	22	62	10	80	38	04	06	12	82	00
57	33	42	19	49	63	04	81	38	09	05	35	82	36
58	34	00	19	16	63	57	82	38	14	04	58	83	43
59	34	13	18	42	64	49	83	38	17	04	20	84	31
60	34	33	18	06	65	41	84	38	21	03	44	85	18
61	34	47	17	34	66	33	85	38	23	03	06	86	05
62	35	05	17	00	67	24	86	38	26	02	28	86	52
63	35	18	16	25	68	16	87	38	28	01	52	87	39
64	35	34	15	50	69	07	88	38	29	01	15	88	26
65	35	43	15	15	69	57	89	38	29	00	37	89	13
66	36	00	14	40	70	47	90	38	30	00	00	90	00

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A TABLE of Meridional Angles.

Hor. Dial. Lat.	xi. i.		x. ii.		ix. iii.		viii. iv.		vii. v.		vi.		*South Dial Lat.*
	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.	
0	0	0	0	0	0	0	0	0	0	0	0	00	90
1	0	16	0	34	1	0	1	44	3	44	90	00	89
2	0	32	1	9	2	0	3	27	7	25	90	00	88
3	0	48	1	44	3	0	5	11	11	3	90	00	87
4	1	5	2	19	4	0	6	54	14	36	90	00	86
5	1	20	2	52	4	58	8	35	18	1	90	00	85
6	1	36	3	27	5	58	10	16	21	19	90	00	84
7	1	52	4	3	6	57	11	55	24	27	90	00	83
8	2	8	4	37	7	55	13	33	27	23	90	00	82
9	2	23	5	9	8	54	15	10	30	17	90	00	81
10	2	40	5	43	9	51	16	44	32	55	90	00	80
11	2	55	6	17	10	48	18	17	35	27	90	00	79
12	3	11	6	51	11	45	19	40	37	49	90	00	78
13	3	27	7	24	12	41	21	17	40	1	90	00	77
14	3	43	7	57	13	36	22	44	42	4	90	00	76
15	3	58	8	30	14	31	24	0	44	0	90	00	75
16	4	13	9	2	15	25	25	31	45	49	90	00	74
17	4	29	9	35	16	26	26	52	47	26	90	00	73
18	4	44	10	8	17	10	28	9	49	4	90	00	72
19	4	59	10	39	18	2	29	25	50	33	90	00	71
20	5	14	11	10	18	53	30	39	51	55	90	00	70
21	5	29	11	41	19	44	31	50	53	9	90	00	69
22	5	44	12	12	20	32	32	58	54	21	90	00	68
23	5	59	12	43	21	20	34	5	55	30	90	00	67
24	6	13	13	13	22	8	35	10	56	37	90	00	66
25	6	28	13	43	22	55	36	12	57	34	90	00	65
26	6	42	14	12	23	40	37	13	58	34	90	00	64

A TABLE of Meridional Angles.

Hor. Dial La.	xi.	i.	x.	ii	ix.	iii.	viii.	iv.	vii.	v.	vi.		*South Dial La.*
	d.	m.	d.	m.	d.	m.	d.	m.	d.	m	d.	m.	
27	6	56	14	41	24	25	38	11	59	27	90	00	63
28	7	10	13	10	25	9	39	7	60	17	90	00	62
29	7	24	15	40	25	52	40	2	61	4	90	00	61
30	7	38	16	6	26	33	40	54	61	49	90	00	60
31	7	50	16	34	27	15	41	44	62	30	90	00	59
32	8	5	17	1	27	55	42	30	63	11	90	00	58
33	8	19	17	27	28	34	43	20	63	49	90	00	57
34	8	31	17	54	29	13	44	5	64	24	90	00	56
35	8	44	18	20	29	50	44	49	64	58	90	00	55
36	8	57	18	49	30	27	45	31	65	30	90	00	54
37	9	10	19	9	31	2	46	12	66	10	90	00	53
38	9	22	19	34	31	37	46	50	66	29	90	00	52
39	9	34	19	58	32	11	47	28	66	56	90	00	51
40	9	45	20	21	32	44	48	7	67	21	90	00	50
41	9	57	20	44	33	16	48	39	67	47	90	00	49
42	10	10	21	7	33	46	49	12	68	11	90	00	48
43	10	22	21	29	34	18	49	44	68	33	90	00	47
44	10	32	21	51	34	47	50	10	68	54	90	00	46
45	10	44	22	12	35	17	50	46	69	15	90	00	45
46	10	54	22	33	35	44	51	15	69	35	90	00	44
47	11	5	22	53	36	11	51	42	69	53	90	00	43
48	11	17	23	13	36	37	52	9	70	11	90	00	42
49	11	25	23	33	37	3	52	35	70	28	90	00	41
50	11	35	23	52	37	28	53	00	70	43	90	00	40
51	11	45	24	9	37	52	53	24	70	59	90	00	39
52	11	55	24	27	38	15	53	46	71	13	90	00	38
53	12	5	24	43	38	37	54	12	71	28	90	00	37
54	12	13	25	2	38	58	54	29	71	41	90	00	36
55	12	22	25	18	39	19	54	49	71	54	90	00	35
56	12	32	25	34	39	40	55	9	72	5	90	00	34
57	12	40	25	50	39	50	55	28	72	17	90	00	33
58	12	48	26	5	40	01	55	45	72	28	90	00	32

A TABLE of Meridional Angles.

Hor. Dial. Lat.	xi. i.		x. ii.		ix. iii.		viii. iv.		vii. v.		vi.		*Sout. Dial Lat.*
	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.	
59	12	56	26	20	40	36	56	3	72	38	90	00	31
60	13	4	26	34	40	54	56	19	72	48	90	00	30
61	13	11	26	47	41	10	56	34	72	58	90	00	29
62	13	19	27	1	41	21	56	49	73	7	90	00	28
63	13	26	27	13	41	42	57	3	73	15	90	00	27
64	13	32	27	25	41	57	57	17	73	24	90	00	26
65	13	36	27	37	42	15	57	30	73	32	90	00	25
66	13	46	27	49	42	25	57	43	73	39	90	00	24
67	13	51	27	59	42	38	57	54	73	46	90	00	23
68	13	57	27	9	42	50	58	5	73	53	90	00	22
69	14	3	28	19	43	2	58	16	73	59	90	00	21
70	14	7	28	29	43	13	58	26	74	5	90	00	20
71	14	13	28	37	43	18	58	35	74	11	90	00	19
72	14	18	28	46	43	24	58	44	74	16	90	00	18
73	14	22	28	54	43	36	58	52	74	20	90	00	17
74	14	27	29	2	43	52	59	00	74	25	90	00	16
75	14	30	29	7	44	00	59	7	74	30	90	00	15
76	14	33	29	15	44	8	59	15	74	34	90	00	14
77	14	37	29	21	44	14	59	22	74	37	90	00	13
78	14	41	29	27	44	22	59	27	74	40	90	00	12
79	14	44	29	32	44	28	59	32	74	44	90	00	11
80	14	47	29	37	44	34	59	37	74	47	90	00	10
81	14	49	29	41	44	37	59	40	74	49	90	00	9
82	14	51	29	45	44	40	59	44	74	51	90	00	8
83	14	53	29	49	44	44	59	47	74	53	90	00	7
84	14	55	29	22	44	48	59	51	74	55	90	00	6
85	14	56	29	54	44	53	59	54	74	57	90	00	5
8	14	57	29	55	44	55	59	55	74	58	90	00	4
87	14	58	29	56	44	56	59	56	74	58	90	00	3
88	14	59	29	57	44	57	59	58	74	59	90	00	2
89	14	59	29	58	44	58	59	59	74	59	90	00	1
90	15	00	30	00	45	00	60	00	75	00	90	00	0

The USE of the

TABLES.

THE Deſign of the firſt Table, (Entituled *A Table of the Three Requiſites in Dialling, for Latitude* 51 *Degrees,* 30 *Minutes)* is to ſave the Trouble of Calculation, according to the Directions given elſewhere in this Book, and is adjuſted to Latitude 51 deg. 30 min. and to all Declinations in that Latitude. Its Uſe is, if it is required to make a Dial for Latitude 51 deg. 30 min. to decline any Number of Degrees from the Meridian, ſeek the Declination in the firſt Column, entituled, *(Declination)* and againſt it in the ſecond Column, you have the Subſtile's Diſtance from the Meridian: In the Third you have the Height of the Stile, or the Angle that the Stile makes with the Plain; and in the fourth Column, you have the Inclination of Meridians, or what is by ſome called the Plain's Difference of Longitude ready calculated.

EXAMPLE.

It is required to make a Dial for Latitude 51 deg. 30 min. to decline from the Meridian 36 deg. (it is no Matter in this Caſe, whether the Declination be Eaſt or Weſt, the Requiſites being the ſame in Quantity in both, only upon different Poſitions,) I look in the firſt Column, entituled, (*Declination*) for 36 Degrees the Declination propoſed, and I find againſt it in the ſecond Column 25 deg. 4 min. for the Subſtile's Diſtance from the Meridian, or the Angle, which the Subſtile makes with the Meridian, or perpendicular Line of the Plain. In the third Column I find 30 deg. 14 min. for the Height of the Stile, or the Angle that the Stile makes with the Plain of the Dial. In the third againſt 36 deg. you find 42 deg. 52 min. for the Inclination of Meridians, or the Plain's Difference of Longitude, which being all found by Inſpection in the Table, you may proceed to make your Dial as elſewhere directed in this Book, and that without any more Trouble of Calculation.

And by the ſame Rule, if you would make a Dial for the aforeſaid Latitude of 51 deg. 30 min. to decline from the Meridian 86 deg. you find in the Table the Subſtile's Diſtance from the Meridian is 38 deg. 26 min. the Stile's Height is 2 deg. 28 min. and the Inclination of Meridians is 86 deg. 52 min. But in this Caſe, the Height of the Stile is ſo ſmall, that it is beſt to make the Dial without a Center; of which before.

THE ſecond Table, entituled (*A Table of Meridional Angles*) contains eight Columns, of which the firſt contains the Latitude propoſed for a Horizontal Dial; and the laſt is the Complement thereof, which is alſo the Latitude for direct South Dials; it is of Uſe in both ſorts of Dials.

EXAMPLE.

I would make a Horizontal Dial for Latitude 54 Degrees. I look in the firſt Column of the Table under (*an Horizontal Dial Latitude*) for 54 Degrees, and againſt it in the ſecond Column, I find 12 Degrees 13 Minutes, and over the Top of that Column xi. i. which ſhews, that the Hour-lines of 11 and 1 make an Angle with the Meridian of 12 Degrees, 13 Minutes. In the third Column, you have 25 Degrees, 2 Minutes, and over that Column is x. ii. *viz.* the Hour-lines of 10 and 2, make an Angle with the Meridian of 25 Degrees, 2 Minutes, and conſequently, the Hour-lines of 9 and 3, make Angles with the Meridian of 38 Degrees 58 Minutes. The Hour-lines of 8 and 4 make Angles of 54 29, the Hour-lines of 7 and 5, make Angles of 71 and 74, the Hour-line of 6 making always right Angles with the Meridian.

EXAMPLE.

IF you would make a direct South Dial, the Rule is the ſame, only you are to find the given Latitude on the right Hand, or Column of the Table, and proceed as before; as ſuppoſe you would make a South Dial for Latitude 40 deg.

you find in the Table againſt 40, in the laſt Column, that the Hour-lines of 11 and 1, make Angles with the Meridian of 11 Degrees, 35 Minutes, the Hour-lines of 10 and 2 make Angles o 23 Degrees 52 Minutes; and ſo in the reſt, as i the Table, the Hours on a South Dial being to b numbred contrary to thoſe of a Horizontal Dia as hath been ſufficiently taught in the former Par of this Book.

F I N I S.